# VISUAL OUTCOME IN CONGENITAL AND DEVELOPMENTAL UNILATERAL CATARACTS

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# CERTIFICATE

This is to certify that this dissertation entitled "**VISUAL OUTCOME IN CONGENITAL AND DEVELOPMENTAL UNILATERAL CATARACTS"** submitted for MS (Branch III) Ophthalmology March 2007, The Tamil Nadu Dr. MGR Medical University, is a bonafide work done by **Dr. Lakshmi.C,** under our guidance and supervision in the Paediatric Ophthalmology and Strabismus Department of Aravind Eye Care System and Postgraduate Institute of Ophthalmology, Madurai during her residency period from May 2004 to April 2007.


**Dr. P. Vijayalakshmi**

Chief, Paediatric Ophthalmology and Strabismus
Aravind Eye Hospital
Madurai

**Dr. M.Srinivasan**
**Director**

Aravind Eye Hospital
Madurai

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# CONTENTS

# INTRODUCTION

Cataracts are one of the treatable causes of visual impairment during infancy[1] and childhood. Early surgery and optical correction have resulted in improved visual outcome[1] though questions arise concerning patient selection, surgical technique, management of posterior capsule opacification, selection of a suitable IOL design, material and IOL power calculation in view of expected eye growth and management of amblyopia[2].

During the first two years of life the progressive increase in axial length and changes in corneal curvature make it more difficult to select the appropriate implant power and have led to the common practice of IOL power implantation only in children older than 2 yrs[3]. But there are studies to show that with proper case selection and surgical technique , IOL insertion with cataract surgery can be performed relatively safely in infants also[4].

Intraocular lenses in children has it's own peculiar set of complications, management solutions and secondary surgical procedures. These complications are compounded because infants and small children are unable to co operate with many examinations and treatment modalities unless they are performed under general anaesthesia. The exuberant post operative inflammatory response of the paediatric eye and the high incidence of secondary membrane formation further complicates postoperative course[6]

Lens implantation is reserved for children who become non compliant to the use of contact lenses or in whom the patient, parent or the ophthalmologist judge that successful contact lens wear will not be achieved and also in children with ***unilateral cataracts***[5]. An IOL is contraindicated in a child with only one eye. Other contraindications are patients with microphthalmia, corneas less than 10 mm in diameter, aniridia, congenital glaucoma, chronic intraocular inflammations and posterior pole defects precluding useful vision[6].

Cataract surgery without IOL implantation will require the patient to use contact lenses or aphakic glasses postoperatively. These treatments have proved unmanageable for many children especially those below two years [4]. Hence IOL remains to play an important role in the optical correction of paediatric aphakia[6].

# REVIEW OF LITERATURE

***1. Visual results after early surgical treatment of unilateral congenital cataracts*** (Kenneth. P. Cheng. MD, David Hiles, MD, Albert W. Biglan, MD, Milton C. Pettapiece, MD, Opthalmology 1991 (98); p- 903-910.

In a review of 25 patients who had been operated on for unilateral congenital cataracts at 1yr of age or young with a 5yr or longer follow up 5 eyes achieved 20/40 or better snellen acuity, 5 eyes achieved 20/50 – 20/100, 15 eyes had 20/200 or less visual acuity. All patients with visual acuity of 20/40 or better had cataract surgery done before 17 weeks of age. The mean intervals from birth or surgery until a successful optical correction of aphakia was achieved were longer for the patients with visual acuity of less than 20/200. Seven patients had strabismus preoperatively and six of them had best corrected visual acuity of 20/200 or less.

***2. Long term follow up of Eye Growth in Paediatric patients after unilateral cataract surgery with intra ocular lens implantation.*** (Inatomi et al: Journal of American Association of Paediatric Opthalmology & Strabismus Feb. 2004 p- 50).

Refractive state, refractive power of cornea and axial length were measured both in operated and non-operated eyes in 15 patients after unilateral cataract surgery and followed up for a mean of 9 yrs. Mean age at surgery was

10.3yrs. In 79% of patients visual acuity was 20/40 or better. Myopic changes were noted in the operated eyes but there was no significant differences in axial length or refractive power of the cornea between operated and non operated eyes.

***3. Prospective analysis of pediatric pseudophakia, myopic shift and postoperative outcomes.*** (Eric R. Crouch et al. Journal of American Association of Paediatric Opthalmology & Strabismus October 2002).

In a prospective study of refractive errors of all paediatric patients 12 months – 18 years who had cataract surgery and intra ocular lens implantation were evaluated with a minimum 3 year follow up. In unilateral cataracts visual acuity of 20/50 or better was seen in 74% of eyes. The greatest refractive growth occurred in youngest operated eyes, primarily 1-3yrs. Myopic shift was more significant with a longer follow up of 5.45 yrs.

***4. Out come and complications of intraocular lenses in children with cataract*** (D. Knight Nanan et al Journal of Cataract and Refractive Surgery Volume. 22. July / August 1996).

In a prospective study comprising of 24 eyes of 20 patients, aged 4 weeks to 12 yrs who had extra capsular cataract extraction and posterior chamber intraocular lens implantation with a mean follow up of 103 weeks, the developmental cataract group attained a visual acuity of 6/24 or better in 64%

and postoperative complications occurred in 29.2% cases (excluding PCO). PCO occurred in 95.8% of eyes. They concluded that with careful management and patient selection, the use of intraocular lens in children can produce good visual results with minimum of complications and changes in refraction.

They used an intraocular lens which was lower by 6.0D than the one needed for emmetropia to compensate for the expected myopic shift. Five of the patients were even seven weeks or younger.

***5. Role of posterior capsulotomy with vitrectomy and intraocular lens design and material in reducing posterior capsule opacification after paediatric cataract surgery.*** (Jagat Ram et al: Journal of Cataract and Refractive Surgery 2003).

Sixty four eyes of 52 children ranging in age from 3 months to 12 years who had cataract extraction with intraocular lens implantation were prospectively evaluated for a minimum postoperative period of 2 yrs. The conclusions drawn were that the management of the posterior capsule rather than intraocular lens design and material that influences the incidence of PCO after cataract surgery in children and this serves the main objective of paediatric cataract extraction ; that is to prevent deprivation amblyopia.

***6. Prevalence of good visual acuity following surgery for congenital unilateral cataract.*** (Elieen E.Birch, David. R.Stager et al. Archives of Ophthalmology – Volume 106, Jan 1988).

Of the patients examined 53% of patients obtained linear distance acuities of 20/80 or better by 3-yrs of age. The best outcomes followed surgery during the first two months of life, prompt lens fitting, aggressive occlusion therapy and regular follow up. Nonetheless, aphakic eyes did not achieve a visual acuity of 20/20 in the sample. Poor visual outcomes following late surgery appears to be due to development of amblyopia during the first months of life, which may aggravate compliance problems and further deteriorate prospects of visual rehabilitation. The preponderance of early surgeries in this report may partly explain the high percentage of successful visual rehabilitation attained.

***7. Interocular axial length difference in eyes with paediatric cataracts.*** (Garima Lal, Rupal H. Trivedi et al, Journal of American Association of Paediatric Ophthalmology and Strabismus Volume – 9 (4) August 2005).

This study evaluated the interocular axial length difference between the operated eye and fellow eye at the time of paediatric cataract surgery. The mean patient age at surgery was 56.9 months (range 0.2 – 230.0). The mean interocular axial length difference in unilateral cases was 0.10 ± 1.33 mm (p =

0.4). Absolute values was 0.98 ± 0.9 mm. They concluded that interocular axial length difference of ≥0.5mm occurred in 48% of patients with paediatric cataracts and occurred more often with unilateral cataracts than bilateral cataract. In patients with unilateral cataract, age at surgery and axial length of the operated eye could help predict the interocular axial length difference.

***8. Unilateral Pseudophakia in children under 4 years.*** (Sten Awner, Edward G. Buckley et al. Journal of Paediatric Ophthalmology and Strabismus. 1996 ; 33 ; P 230 – 236).

This study evaluated the efficacy of intraocular lens implantation in children younger than 4 years of age for unilateral aphakic visual rehabilitation. Overall age at surgery averaged 26 months with a follow up of 5-55 months. 42% of children in the infantile group attained 20/40 or better vision. Intraocular lens power averaged 22.6D. An increasing myopic shift was seen n the infantile group. Amblyopic therapy was completed successfully in half the patients. They concluded that primary intraocular lens implantation is an effective way to rapidly achieve aphakic visual rehabilitation in preschool children.

***9. Intraocular lens implantation in children with monocular cataracts.***

(Davis A. Hiles. Ophthalmology October 1984. Volume 91 No: 10)

In this study 135 patients had infantile cataracts (lens opacity at birth or arising any time prior to the eighth birthday). Of them 17% of patients achieved 20/20 to 20/40 visual acuity 27% achieved 20/50 – 20/100, 17% patients had 20/200 or less visual acuity and 39% patients had 20/200 or less visual acuity. 18% patients had posterior lenticonus, microcornea occurred in 16% and Persistent hyperplastic primary vitreous in 14%. Preoperative strabismus was present in 16% of the patients and nystagmus was present in 10% of patients. The three patients in the 20 / 20 to 20 / 40 group was implanted between 1-2 yrs of age (primary implantation). No infantile cataract achieved 20/20 – 20/40 when implanted before one year but poor outcome was considered to be due amblyopia because of the dense cataract. The earliest intraocular lens implanted was at 4 months of age in this study. They concluded that intraocular lens is a safe and effective aphakic rehabilitative method for children if the surgeon utilizes proper case selection, technique and diligent postoperative therapy with glasses, bifocals, occlusion and secondary surgeries when needed.

***10. Intra ocular lenses in children, changes in axial length, corneal curvature and refraction.***(DI Flitoroft, D Knight Nanan et al British Journal of Ophthalmology 1999; (83) 265 - 269).

This study assessed 35 eyes of 24 patients with congenital or developmental cataracts who underwent extra capsular cataract extraction and posterior chamber intraocular lens implantation. In the congenital cataract group (<1yr age of onset), over the mean follow up period of 2 yrs the mean increase in axial length of 3.41 mm was not significantly different form the expected mean growth of 3.44mm (paired t test, p=0.97). In the developmental cataract group (onset > 1yr of age) the mean age at surgery was 6.4 years with a mean follow up of 2.86 yrs and the mean growth in axial length of 0.36mm which not significantly different from the expected value of 0.47 mm (paired t test p = 0.63). The mean keratometry at final follow up was 46.15D and 43.63D for the congenital and developmental age group respectively. They concluded that the pattern of axial elongation and corneal flattening was similar in congenital and developmental group and there was no retardation or acceleration in eyes implanted with intraocular lens. A myopic shift was seen particularly in eyes operated on at 4-8wks of age and a 6D hypermetropic correction is recommended initially with spectacle correction of the residual refractive error.

# EPIDEMIOLOGY

It is estimated that there are 1.5 million blind (corrected visual acuity less than 6/120 in the better eye) children in the world with a prevalence of between 1 to 4/10,000 children in industrialized countries and 5 to 15/10,000 children in developing countries[7,8]. The prevalence of cataract in childhood has been reported as 1 to 15/10,000 children .Given a birth rate of 2% approximately 4 children /million total population per year will be born with bilateral cataract in industrialized countries. In developing countries it is likely to be 10 /million total population per year. Prevalence of blindness (best corrected visual acuity less than 3/60) due to cataract in children in developing countries is probably 1 to 4 /10,000 and approximately 0.1 to 0.4 / 10,000 in the industrialized countries.

The difference reflects the better prognosis for vision obtained when children are diagnosed early and managed by paediatric ophthalmologists[9].

# LENS EMBRYOLOGY AND GROWTH

The morphology of the lens is largely determined by the anatomy of the lens and the timing and nature of the insult that caused the abnormality by altering the embryogenesis. Both fibroblast growth factor and PAX 6 gene are critical for the in utero development of the lens[70].

The lens placode appears on the optic vesicle around the 25$^{th}$ day of gestation as a thickening of the surface ectoderm, a single layer of cuboidal cells that invaginate into the neural ectoderm of the optic vesicle as the lens pit, becoming free from the surface by the 33$^{rd}$ day. The posterior cells elongate as primary lens fibres that obliterate the lumen of the lens vesicle. This becomes a spherical optically clear embryonic nucleus of 0.35mm diameter which stays unchanged throughout life and is seen inside the Y sutures in the fully developed eye.

Equatorial secondary lens fibres derived from the anterior epithelium grows anteriorly and posteriorly to meet each other at the sutures which can be seen easily with a slit lamp microscope as an upright anterior Y and an upside down posterior Y. Fibroblast growth factor may induce this differentiation. After birth the equatorial fibres grow to form the cortex meeting at less well marked sutures. The tertiary vitreous condenses within the space between the

ciliary body and the lens equator to form the suspensory ligament of the lens at the fifth month of gestation.

The developing lens derives nutrition through the tunica vasculosa lentis supplied by the hyaloid artery , a branch of the primary dorsal ophthalmic artery and anteriorly from an anastomosis with vessels in the pupillary membrane. Tunica vasculosa lentis is first seen at about 35 days and most prominently at 65 days. It gradually regresses at about 85 days and by term birth only whispy remnants of the pupillary membrane are left and a vestigial hyaloid artery known as Mittendorf's dot is attached to the axial posterior surface of the lens[10].

# AXIAL LENGTH AND KERATOMETRY CHANGES WITH AGE

According to Gordon and Donzis[84] there is a triphasic pattern of growth in axial length; the greatest increase occurring in the youngest age groups. By the age of 2-3 yrs the rate of growth slows to approximately 0.4mm/year over the next three to four years. After 5-6 years of age the axial length increases approximately 1mm to its adult length. No significant increase in axial length was noted after 10-15 years of age. The keratometry measurements for the younger age group was significantly greater than for all the older age groups, however no significant difference was noted between the age group of 6 months and all the older age groups. This is in marked contrast to axial length and lens power which continues to change significantly after the first year of life.

# MORPHOLOGICAL CLASSIFICATION OF CONGENITAL AND DEVELOPMENTAL CATARACTS

| ANTERIOR | POSTERIOR | INVOLVING THE WHOLE LENS | CENTRAL | OTHERS |
|---|---|---|---|---|
| 1. Anterior polar*<br>• Dotlike<br>• Plaque like<br>• Anterior pyramidal<br>2. Anterior sub capsular<br>3. Anterior lenticonus | 1. Mittendorf's dots<br>2. Posterior lenticonus*<br>3. Posterior cortical<br>4. Posterior subcapsular | 1. Total cataracts*<br>2. Congenital morgagian<br>3. Disk like membraneous | 1. Lamellar / zonular*<br>2. Central pulverulent<br>3. Ant egg cataracts<br>4. Nuclear cataracts<br>5. Cerulean, florifom or coronary cataracts | 1. Punctate lens opacities<br>2. Sutural cataracts<br>3. Coralliform cataracts<br>4. Wedge shaped<br>5. Persistent hyperplastic primary vitreous* |

* Morphological patterns that can be seen in unilateral cataracts

The morphological classification of cataracts will help in suggesting a probable etiology eventhough not always[1].It may also help in predicting the visual prognosis[1] Cerulean and pulverulant cataracts show allelic heterogeneity although the abnormality is in the same locus as chromosome 13[1]. In contrast as

is the case of anterior polar cataracts the same morphology can be the consequence of alterations in different loci in different chromosomes[1].Certain phenotypes (lamellar, pulverulant polymorphic, coralliform and cortical) seem to have good visual prognosis .PAX6 mutation can occasionally cause anterior polar cataracts without aniridia[1].

## A. ANTERIOR CATARACTS:

Anterior polar cataracts are usually ***unilateral***[73], frequently hereditary and even seen in an isolated case may be a new mutation with recurrence risks to the patient's children.

### 1.ANTERIOR POLAR CATARACTS

#### *a. Dot like anterior polar cataracts*

These relatively common opacification are seen as tiny white dots on the anterior surface of the lens in the axial area that probably represent anomalies of lens vesicle detachment, they can be unilateral or bilateral; when bilateral they are usually symmetrical. They are composed of tiny dots sometimes formed like a star (cataracta stellata). They are often not visually significant by themselves but may be associated with refractive errors which may cause amblyopia and strabismus. Usually static they may occasionally progress becoming visually significant requiring surgery.

Some cases are inherited as autosomal dominant trait. They have been described in association with a familial 3:18 and a 2:14 chromosomal translocation. A new locus has been identified on the short arm of chromosome 17 .They are very frequent with aniridia and have been reported in association with retinoblastoma and cerebral malformations and cornea guttata.

***b.Plaque like anterior polar cataracts***

These are caused due to abnormalities of pupillary membrane regression. They may be associated with corneal opacities. Management is similar as in dot like variety. Dilating the pupils may sometimes improve vision.

***c.Anterior pyramidal cataracts***

These are severe forms of dot like opacities, and probably also represent anomalies of the lens vesicle detachment, they are larger axial opacities and may extend anteriorly and rarely fuse with the cornea, and may have an associated corneal opacity. They are usually visually significant, bilateral and symmetrical and can progress. They can also detach and form an anterior chamber foreign body. Histological studies have shown a reduplication of the lens capsule that surrounds a polar opacity , composed of spindle shaped epithelial cells and collagen fibrous tissue , with a notable absence of epithelial cells at the base of the pyramidal opacity with an extremely thin anterior

capsule separating the cataract from the anterior cortical lens fibres. When hereditary, dominant inheritance is the rule.

**2.ANTERIOR SUBCAPSULAR CATARACTS**

These are usually associated with acquired disease such as uveitis, trauma, irradiation or atopic skin disease. It can also be associated with Alport's syndrome or with pulverulent cataracts.

**3.ANTERIOR LENTICONUS**

It is less common than posterior variety and it is more frequently encountered in association with Alport's syndrome of nephritic haematuria and deafness. The lenticonus may be a manifestation of basement membrane disorder and it can be congenital. Cataracts are usually not associated unless anterior capsule ruptures. Anterior lenticonus may also be associated with Lowe's and Waardenberg's syndrome .Even if there is no lens opacities high astigmatism due to the lenticonus may affect the vision significantly requiring surgery. Bilateral anterior lenticonus may be associated with Alport's syndrome[74] .

**B. POSTERIOR CATARACTS**

Some posterior cataracts such as mittendorf's dots and posterior lenticonus have good visual prognosis whereas other posterior cataracts, if congenital may be associated with poor visual prognosis. Posterior polar

cataracts are more visually significant than anterior polar cataracts and are often not detected until a later age.

**1.MITTENDORF'S DOTS**

It is also known as hyaloid body, represents the remains of anterior end of the hyaloid artery. It appears as a small axial or nasally paraxial grey white dot opacity at the posterior apex of the lens , often associated with a thread like structure, which represents the anterior end of the hyaloid artery.Usually visually insignificant it may rarely represent a mild form of persistent hyperplastic primary vitreous (PHPV).Other associations are persistent hyaloid artery and posterior lenticonus.

**2.POSTERIOR LENTICONUS**

Posterior lenticonus or lentiglobus is usually unilateral with thinning and posterior bowing of the posterior lens capsule centrally or peripherally. It is a result of a defect in the posterior lens capsule with secondary bulging and opacification of the underlying lens. It may cause high degree of astigmatism that can be irregular but without cataract. It may be present at birth or progress in the first months of life and continued surveillance is needed. Amblyopia is frequently present but vision may be improved by postoperative occlusion. Although sporadic cases may exist many are inherited as x-linked or autosomal dominant trait. Slit lamp examination of relatives may be important in some

cases. Posterior lenticonus may be associated with microcornea, hyperglycinuria, Duane's syndrome and anterior lentiplanus.

**3.POSTERIOR CORTICAL CATARACTS**

Nettleship and Ogilvie described this as a flat sharply defined ,circular disc lying between the posterior pole and the nucleus sometimes involving the posterior suture in a faint inverted Y .Posterior cortical lens opacities were found in combination with anterior lens opacities in the congenital disinsertion syndrome and some of the lenses showed a lens coloboma also in the lower nasal quadrant. These opacities may be ***unilateral***.

**4.POSTERIOR SUBCAPSULAR OPACITIES**

Posterior subcapsular opacities can be described as vacuolar or plaque opacities; the former being closer to the posterior capsule and the latter more cortical. Major histopathological change in the plaque type is the breakdown of the normally regular parallel rows of lens fibres into rounded globules. Plaque type opacities may be seen in congenital cataract, myotonic dystrophy and Turner's syndrome .It is an important type of cataract as it causes decreased visual acuity early due to ints central or axial posterior postion.Posterior subcapsular opacities adhering to suture lines may be found in Fabry's disease. Posterior subcapsular cataracts of presenile onset occurs in Neurofibromatosis type 2.

## C . PERSISTENT HYPERPLASTIC PRIMARY VITREOUS

It is often associated with congenital cataract ***especially unilateral*** .It consists of a developmental abnormality of the primary vitreous and hyaloid vascular system. The cardinal features suggested by Goldberg are persistent pupillary , iridohyaloid blood vessels, persistence of the posterior fetal fibrovascular sheath of the lens , a Mittendorf dot, a persistent vasa hyaloidea propria and hyaloid artery , a Bergmeister's papilla , congenital non attachment of the retina ,macular abnormalities , optic nerve hypoplasia and dysplasia and malformations of the size and shape of the globe. There is a membrane of variable extent and thickness behind and usually inseperable from the lens that it is attached via the apices of its scalloped margins to the ciliary processes. The hyaloid vessels may be large but only very occasionally there is significant flow and leakage from this vessel may cause intralenticular haemorrage. The lens itself may be of normal size which gives rise to a shallow anterior chamber and as the retrocorneal membrane shrinks and thrusts it forward; if happening in the first months of life gives rise to glaucoma. The lens may spontaneously reabsorb making the anterior chamber deeper but the eye is still said to be at risk of dislocation of the ciliary body and hypotony as the membrane is very thick. Systemic disease is so rare in unilateral PHPV but in bilateral cases isolated PHPV must be isolated from the vitreoretinal dysplasias such as

Norrie's disease and Walker Warburg syndrome. It can be recognized by the hallmark ultrasound feature of a scalloped edged membrane and stretched ciliary processes in a microphthalmic eye .The indications for surgery are threefold: first to prevent the complications of glaucoma and hypotony, second for cosmesis and third for vision. In an infant visual prognosis may be sufficiently good .If early surgery and amblyopia therapy are done the visual results are better in milder cases. The surgery consists of removal of lens and the membrane with a vitrectomy machine .Incidence of glaucoma, haemorrage and retinal detachment are significantly more than uncomplicated cataract surgery. Intraocular lenses have been used but except in the mild cases the added risks due to PHPV itself make optical correction with contact lenses the best approach.

**D .CATARACTS INVOLVING THE WHOLE LENS :[10]**

Cataracts involving the whole lens are often of early onset and if so have a profound effect on the visual prognosis and they may demand early surgery.

**1.<u>TOTAL CATARACTS</u>**

It represents a generalized opacity of all the lens fibres .It can be completely opaque while first diagnosed or it can develop from lamellar or nuclear cataracts and posterior lenticonus. They are frequently bilateral also and may progress. Cataracts involving the whole lens may occur in acute metabolic cataracts, in congenital rubella (where shaggy nuclear cataracts are more

common) and also in familial or sporadic cases as well as in some rare syndromes. Aggressive surgical management is necessary if good visual outcome is to be achieved. Total cataracts may also be a cause of cosmetic concern.

**3.DISK – LIKE MEMBRANEOUS CATARACTS**

It represents various stages of reabsorption of the lens which leaves either a disk of lens material or a bag of milky or crystalline substance. The anterior and the posterior capsules fuse together(membraneous cataract) .It has been described in congenital rubella syndrome , Hallerman -Streiff syndrome ,PHPV , aniridia , Lowe's syndrome and Pierre Robin sequence .It can also occur after rupture of anterior lenticonus. When the reabsorption occurs centrally ,the lens may take the shape of a hollow doughnut .

**2.CONGENITAL MORGAGNIAN CATARACTS**

These are uncommon total dense cataracts named after Giovanni Morgagni who described them in 1762; the outer zones of the lens become liquefied , while the nucleus remains intact. This allows the nucleus to fall down by gravity. Eventually the fluid may be reabsorbed so that the anterior and posterior capsules adhere above the displaced nucleus, and may even completely reabsorb.

**E .CENTRAL CATARACTS:**

**1.LAMELLAR OR ZONULAR CATARACTS**

Lamellar or zonular cataracts are common forms which involve more than one layer of the lens , and not involving the embryonic nucleus but may involve the fetal nucleus. They are sharply separated from the clear cortex outside them one or more layers or zones of the lens as a shell of opacity sandwiched between clear nucleus and cortex. It represents several generations of secondary lens fibers, which have become opacified in response to and insult when these fibers were at their most metabolically active period. The opacity may be dense, or translucent that vision is hardly if at all impaired. They are often inherited as autosomal dominant trait. Typically they are bilateral ***but can be unilateral or slightly asymmetrical.***

They are often incomplete and may have projections from their outer edges known as riders or spokes. Zonular cataracts have been mapped on chromosome 1q. The zonular pulverulant has been mapped to chromosome 1q and 13q.In general lamellar cataracts have a better prognosis than other morphological types. Some may not need surgery also. However if it is central dense and developed during early lens development it may cause profound amblyopia.

**2.CENTRAL PULVERULENT CATARACTS**

It is composed of myriad (pulverized) tiny dots .They are nonprogressive, usually bilateral and vision is rarely affected. It is caused by mutation in the gamma crystallin and the locus has been linked to chromosome 16.

**3.ANT EGG CATARACTS**

A central cataract, composed of larger grainy white dots that are caused by secondary calcification, known as ant egg cataracts have been described recently.

**4.NUCLEAR CATARACTS**

These are opacities of more or less the entire embryonic or fetal nucleus and are not highly visually significant. The density varies .They are static as the lens grows, the central opacity becoming less significant. They are usually bilateral. Francis et al have recently identified a locus for isolated cataract on chromosome Xp22.

**5.CERULEAN , FLORIFORM OR CORONARY CATARACTS**

These opacities have in common a sky –blue or sea green (cerulean) hue and can be observed on slit lamp examination . They are autosomal dominant, early onset , bilateral , largely stationary and visually insignificant cataract. The cerulean cataract is genetically mapped at chromosome region 17q24 and

22q11.2-q13.1 Coronary cataracts are concentrated in a crown like ring around the equator of the lens. Koby's floriform cataract, an autosomal dominant form seen around the sutures with oval or annular elements, like the petals of a flower has been described.

**F . SUTURAL CATARACTS**

Opacities around or involving the sutures ,more posterior than anterior are very common and not usually visually significant. In general they are stationary ,usually bilateral and familial. When there is opacification of anterior and posterior sutures they are called stellate cataract. If all three sutures are affected equally then they are referred to as cataracta triradiata. They may be inherited as autosomal dominant or x-linked recessive trait. and have been found in the female carriers of Nance-Horan syndrome , with affected males presenting with total congenital cataracts.

**G . PUNCTATE LENS OPACITIES**

These are characterized by opaque dots scattered throughout the lens quite different to the pulverulent type. They occur in 13-20% of patients with Down's syndrome .It is also seen in Lowe's syndrome. They increase in number with age and these opacities may be seen in normal population also. Linkage analysis has shown alteration at 2q33-35 at the gamma crystalline cluster.

## H . CORALLIFORM OR CRYSTALLINE CATARACTS

These are rare opacities usually static, central, complex cataracts with multiple coral like white or cerulean opacities. They are often visually insignificant and can be inherited as an autosomal dominant trait.

## I . WEDGE SHAPED CATARACTS

These opacifications occupy a sector of the lens, if they are larger they are known as semilunar.They have been described in Conradi syndrome when it may represent an example of Lyonisation,Stickler syndrome and in neurofibromatosis type 2 and in some cases of Fabry disease.

# ETIOLOGICAL CLASSIFICATION OF PAEDIATRIC CATARACTS

## A.GENETIC

***Unilateral cataracts are more commonly associated with other ocular anomalies (47%) whereas bilateral cataracts are more likely to be associated with systemic diseases and tend to be inherited[77].***

Paediatric cataracts can be inherited as autosomal dominant, recessive or x linked recessive traits. Autosomal dominant cataracts are most commonly bilateral nuclear opacities but variability can be present in the same pedigree. Less commonly anterior polar, posterior polar and posterior lentiglobus cataracts can be inherited autosomal dominantly. In regions where there is a high prevalence of parental consanguinity autosomal recessive traits are more common. Linkage analysis has been used to determine the genetic loci of certain autosomal dominant cataracts. Coppock like cataract has been linked to the gamma E crystallin gene on chromosome 2,Coppock cataract to chromosome 1q21-q25,Marner cataract to 16q22, cerulean cataract to 17q24. The cerulean cataract links closely to the galactokinase gene ,but galactokinase levels in these patients are normal.

## B.METABOLIC

The most common metabolic disturbance causing cataract in infancy is galactosemia. It may be due to galactokinase, epimerase or transferase

deficiency. Alpha mannosidosis can also be associated with early onset cataract.Lamellar cataracts may also develop in children with neonatal hypoglycemia or hypocalcemia. Neonatal hypoglycemia is more common with low birth weight babies.

**C.INFECTIOUS**

Congenital rubella syndrome ,intrauterine toxoplasmosis and herpes simplex infections are some infectious etiologies for cataracts in infants.

**D.SYNDROMIC**

Lowe's syndrome and Hallermann-Streiff –Francois syndrome are few of the syndromes causing infantile cataracts and less frequently with others like Trisomy 21.

**E. PREMATURITY**

Transient cataracts occur occasionally in premature infants. They are usually bilateral and in most cases it clears off over the course of several months .Alden and coworkers suggested that osmotic changes in the lens of these premature infants may have caused it.

**F. TRAUMA**

Cataracts can be caused by blunt or penetrating injury and retinal and optic nerve pathology should be ruled out in such cases.

## G. LASER PHOTOCOAGULATION

Christiansen and co workers reported total cataracts following argon laser photoablation of the avascular retina in four infants with threshold retinopathy of prematurity. They suggested that diode laser may lower the risk of cataractogenesis[65] but studies have shown cataracts with diode laser also[66]

## H. RADIATION INDUCED

A radiation dose of 15 Gy has been showed to be associated with a 50% risk of cataract formation[67.] It may develop 1-2 years after the completion of radiation therapy for ocular and periocular tumours and usually causes posterior subcapsular cataract.

## I. MEDICATIONS

Systemic corticosteroids in upto 15% cause posterior subcapsular opacities beyond a cumulative dose of 1000mg of prednisolone or the equivalent[68.]

## J. IDIOPATHIC

Approximately half of all congenital cataracts are idiopathic and the ***percentage in unilateral cataracts is even more higher[69].***

**Most common causes of unilateral infantile cataracts[71]**

1. Idiopathic 80%
2. Ocular abnormalities 10%
    a. Posterior Lenticonus

b. PHPV

c. Anterior segment dysgenesis

d. Posterior pole tumour

3. Traumatic 10%

## Ocular abnormalities associated with congenital cataract[72]

| *Anterior Segment* | *Posterior Segment* |
|---|---|
| Aniridia | Choroideremia |
| Glaucoma | RP |
| Microcornea | PHPV |
| Corneal dystrophy | Wagner vitreoretinal degeneration |
| Microphthalmos | Norrie disease |
| Iris atrophy | Favre vitreoretinal degeneration |
| Anterior cleavage syndrome | Stickler syndrome |
| Peter anomaly | |
| Rieger syndrome | |

# MANAGEMENT OF PAEDIATRIC CATARACTS

## HISTORY:

Initial step is to evaluate the history from the parents to obtain any clue regarding the nature of the cataract, as to whether it is congenital, developmental, traumatic, maternal drug use, infections or exposure to ionizing radiation. History regarding the general health of the child, systemic illness and delayed developmental milestones should also be taken into account. A brief outline of any past ocular diseases and ocular medications used should be elicited[17].

## CLINICAL ASSESSMENT:

GENERAL EXAMINATION

Systemic evaluation of the child is mandatory including pre-anaesthetic evaluation of respiratory and cardiovascular abnormalities. Assessment by a paediatrician may be necessary in case of dysmorphic features or other systemic diseases. Investigation under a geneticist is needed when there is definite hereditary pattern[20].

## VISUAL ACUITY

1. Fixation assessment and CSM notation ( in an infant)

a) Both eyes uncovered: observation for manifest deviation, alternate fixation, abnormal movements, unsteady fixation, nystagmus or searching movements.
b) One eye covered for 3s and fixation behaviour of the uncovered eye observed and then the covered eye is uncovered. This is repeated for the other eye also.

Notation:

C – Central foveal fixation: corneal light reflex when the other eye is covered.

S – Steady fixation of a still target or one that is moved when other eye is covered.

M – Maintained: maintaining fixation with the same eye when the other eye is uncovered and the position should be maintained till the next blink.

2. Preverbal child

There are 3 tests which can be used in assessing visual acuity in preverbal children which are

a) Optokinetic nystagmus: Acuity is measured as the finest grating on a rotating drum that elicited a visible nystagmus response. But limitation is the absence of response may be due to lack of attention and cannot be equated to snellen acuity[39].
b) Preferential looking test: Acuity is measured by identifying the spatial stripe frequencies that were fixated longer than a homogenous field by

75% of infants at a given age. It is a resolution task[40]. Statistical reliability has increased by the two alternative forced choice preferential looking test[41]. In amblyopia children and those with foveal abnormalities resolution acuity is better than that of recognition acuity[42].

c) Visual evoked potential: It can be considered as a transient EEG to give information regarding the surface occipital lobe electrical activity in response to visual stimuli. There are two types – patterned and non patterned .To quantify visual acuity of an infant pattern VEP with a checkerboard , bar or sinusoidal pattern can be used. Pattern reversal VEP technique has suggested a 20/20 equivalent grating between 6-12mths of age.

3.Two –three yrs ( Optotype testing )

Optotype is a symbol that when correctly identified at a given distance i.e., particular subtended angle permits quantification of acuity.

1.Picture optotype : ( Allen figures, Kay picture test) may be most appropriate in 2-5 yrs. One adaptation of the optotype testing is the matching techniques; HOTV chart, Sheridan Gardiner single optotype matching test. This permits the child to identify even if he/she does not know its name.

4.Snellen or M units versus logMAR

LogMAR visual acuity charts eg. ETDRS has become the standard for visual acuity testing in clinical research. The nongeometric progression of letter

sizes in a Snellen fraction complicates parametric statistical analysis as compared to the log scale. Snellen acuity data can be converted to logMAR by taking a base 10 log of the reciprocal of the Snellen acuity fraction.

**REFRACTION**

A cycloplegic refraction is necessary in children

**OCULAR MOTILITY**

Ocular motility and evaluation of strabismus with a cover uncover test is also important in the management.Nystagmus indicates poor visual prognosis[18].

**ANTERIOR SEGMENT EVALUATION**

A slit lamp evaluation of the anterior segment including careful evaluation of pupils should be performed. Special care should be given to recognize problems such as iris abnormalities, synechiae, zonulolysis, posterior lentiglobus, intumescent cataract and anterior or posterior capsule plaque. Intraocular pressure should also be recorded with either tonopen or schiotz and if required under anaesthesia. An applanation reading can be taken if the child is co-operative enough.

**POSTERIOR SEGMENT EVALUATION**

An indirect ophthalmoscopy should be performed if the media allows. An ultrasound B scan may be helpful to rule out major posterior segment abnormalities in hazy media.

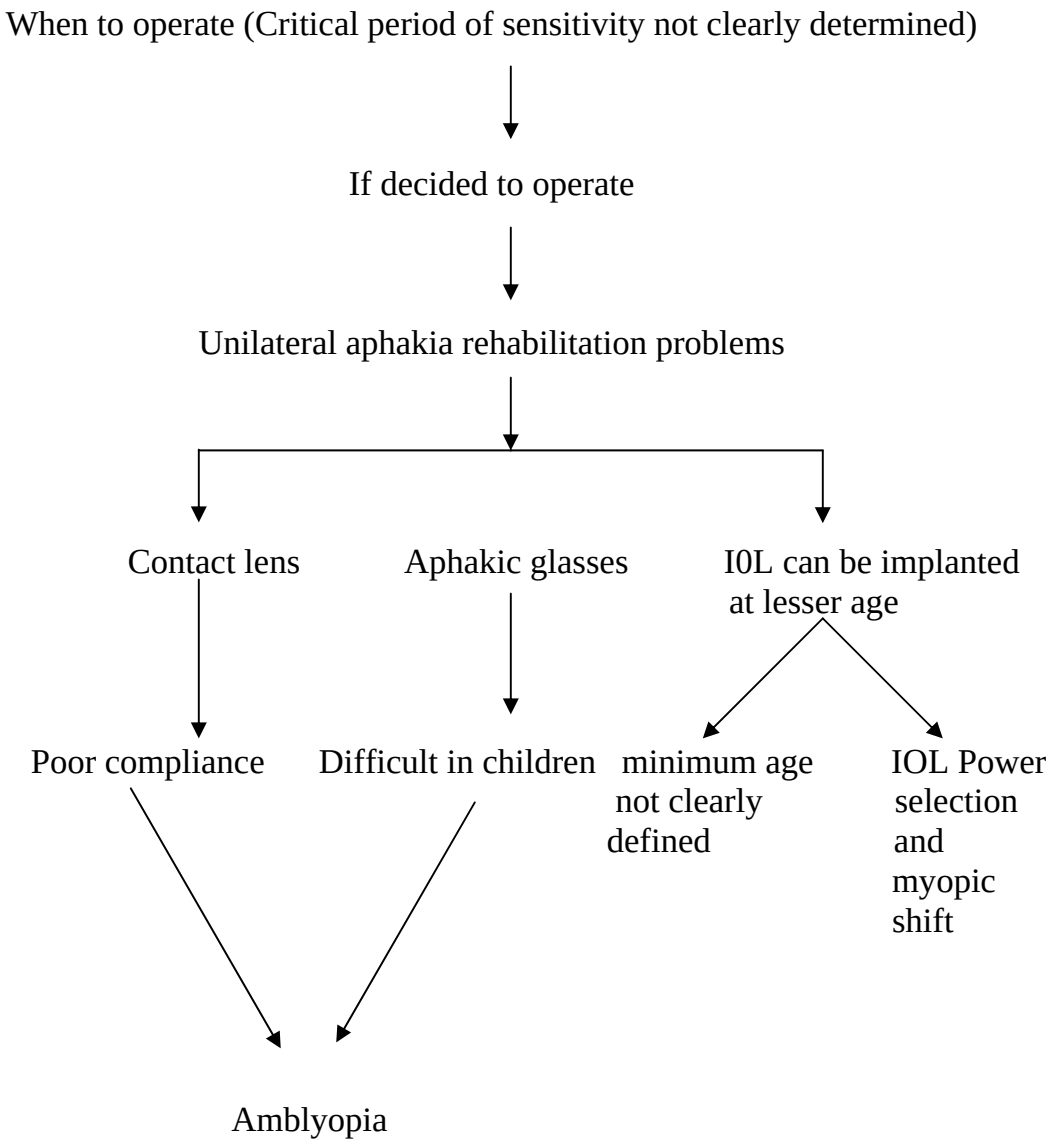
## OTHERS

Axial length and corneal diameter is taken for calculation of IOL power. There are studies showing shorter or longer axial length associated with congenital cataract[19]. Corneal diameter is taken to rule out microcornea and microphthalmos.

## LABORATORY EVALUATION

In a child with congenital cataract but otherwise healthy may not require any laboratory investigations. In a sick child investigations like FBS, plasma calcium and phosphorus urine for reducing sugars may be needed to assess metabolic disorders and fitness for general anaesthesia. TORCH titers for ruling out intrauterine infections and Ig M in saliva for rubella may be necessary in special situations. In suspected cases of Lowe syndrome screening for aminoacidurias is required.

## CONTROVERSIAL FACTORS IN MANAGEMENT OF UNILATERAL CATARACTS




***When to operate?***

The animal models of Hubel and Wiesel and von Noorden and his colleagues conducted in cats and monkeys respectively have demonstrated that visual deprivation from birth to three months of age results in predictable

changes in the development of the animal's visual system. The extent of involvement is related to the age of onset and the duration of visual deprivation. Differences exist between animal and human models in the age during which the visual system is sensitive to visual deprivation and the period of reversibility. The duration of the critical period of sensitivity in humans has not yet been determined. Vaegen and Taylor suggested surgery and optical correction within four months of age and Drummond et al showed that surgery and optical correction must be completed by 17 months of age to obtain a visual acuity of 20/100 (6/30) or better[12].

There is also importance in the type and location of cataracts. Posterior and central cataracts and central nuclear cataracts cause more of visual deprivation[1].It is recommended that all lens opacities of more than 3mm should be removed[13]. In Unilateral partial cataracts surgery is indicated when visual acuity drops below 20/70 (6/18) or in preverbal children when fixation is poor[78]. Though many infantile cataracts are static Nelson et al have shown that some clear over time and some progress[14,15]. If cataract is not visually significant observation alone is appropriate with careful follow up for progression of cataract and development of amblyopia[16].

***Early years***

Initially surgical methods like needling(discission), linear extraction and a combination of discission and displacement of the lens fragment to the anterior chamber by irrigation without IOL implantation[21-24] were in vogue until when Schieie and associates popularized aspiration[25]. Scheie technique left the posterior capsule intact and had problems like secondary membranes and secondary glaucoma due to iris bombe.

In the mid 1960's introduction of the double barreled canula enabled to maintain the anterior chamber depth and keeping the posterior capsule intact[26].The 1970's witnessed the introduction of phacoemulsification in paediatric cataract surgery. Many paediatric cataracts can be removed using the irrigation aspiration handpiece or the phacoemulsification handpiece without ultrasound power[27]

**PARS PLANA APPROACH**

Pars plana lensectomy was an option for paediatric cataracts .Advantages are reduced incidence of vitreous loss and decreased retinal traction as compared to anterior vitrectomy [28] and facilitation of reaching lenticular material in the periphery and less of damage to corneal endothelium and iris tissue[29-30] Disadvantages include loss of integrity of the capsular bag and

elimination of possibility of in the bag IOL placement[29]. Other complications include iatrogenic retinal dialysis and ciliary body detachment[31].

***Paediatric Intraocular lens implantation***

**WHY IOL?**

Aphakic spectacles are debilitating visually and cosmetically and compliance in amblyopia therapy and maintenance of contact lens is poor in developing countries like India [32]. Pseudophakia offers the method of optical correction that requires the least compliance and induces minimal astigmatism and aniseikonia[33].

After Choyce's initial implantation of anterior chamber lenses[44], Binkhorst and Gobin implanted an iridocapsular fixated IOL in 1959[45].With the development of newer lens designs and surgical techniques and various studies showing the safety and effectiveness of IOL implantation this has become the standard procedure for management of paediatric cataract especially unilateral and traumatic cases[5].

Relative contraindications do exist for IOL implantation – glaucoma, persistent or recurrent uveitis ,aniridia, severe microphthalmos ,rubella cataract, other ophthalmic defects that preclude useful vision and cases of inadequate capsular support[46]. Recent studies show that good results can be obtained in

microphthalmic eyes[47].Patient age of <1yr is considered as a relative contraindication for IOL implantation. Although the youngest age at which implants can be safely and effectively used has not been yet established , there are reports of IOL implantation in infants as early as the first two months of life[48].

## POWER OF IOL

It is believed that the growth of anterior segment of eye is generally completed at the end of second year of life[49]. Therefore little adaptation of the size and the strength of the IOL is needed in eyes of children more than 2yrs.Hyperopic undercorrection is often needed in younger children ,although anisometropia should me minimized to promote binocular function.The final hyperopia desired should be correlated to the child's age .

The under correction of 10L power is done on the basis of guidelines given by Dahan et al. In children younger than 1 yr keratometry readings are not crucial as they change rapidly and the keratometry readings can be replaced by the average adult keratometry reading that is 44.OD.

**For children < 2 yrs**

Do biometry and under correct by 20%

Or

Use axial length only

| Axial Length (mm) | 10L power (D) |
|---|---|
| 17 | 28.00 |
| 18 | 27.00 |
| 19 | 26.00 |
| 20 | 24.00 |
| 21 | 22.00 |

**For children between 2 – 8 yrs**

Do biometry and under correct by 10%

***Current Surgical Techniques***

**INFANTS:**

Corneolimbal incision at 10 o'clock and 2 o'clock positions of which one is used for an anterior chamber maintainer attached to balanced salt solution mixed with 1 in 500,000 adrenaline .An anterior central circular capsulotomy of 4-6mm is made with a cystitome and the lens material is aspirated with a lens aspiration canula with a 0.4mm port. Then a posterior capsulotomy with anterior vitrectomy is done with a vitrectomy probe.If no IOL is planned then close with 2 sutures of 10-0 nylon followed by aphakic rehabilitation with glasses or contact lens.If IOL planned then a one piece PMMA lens is placed

after enlarging the wound to allow insertion of IOL under viscoelastic in the fornices of the bag.The section is closed with 10-0 nylon sutures and viscoelastic is aspirated.

**MORE THAN TWO YEARS OF AGE**

**1.Rectus suture and conjunctival incision**

The lid speculum is placed over a sterile drape and superior rectus secured.Limbal based conjunctival flap is made with cauterization of the episcleral vessels.

**2.Paracentesis incision**

This is made temporally at the limbus through which a 0.5mm cyclodialysis spatula and a 30 G canula may be passed.It is used for assisting in IOL placement and to break anterior synechiae and also to aid in 12 o'clock cortex aspiration.But many surgeons avoid a paracentesis incision because it tends to leak in paediatric population.

**3.Limbal incision**

A small scleral scratch incision is made 2.5mm from the limbus and is dissected as a 5.5-6.5mm wide scleral tunnel using a crescent blade. Viscoelastic material is placed to maintain the anterior chamber depth.

**4.Capsulorrhexis**

A continuous capsular rim with the continuous curvilinear capsulorrhexis(CCC) facilitates lens extraction and in the bag placement of IOL. CCC may be achieved with a blunt needle or a cystitome or a forceps. Due to the increased elasticity of the capsule a small central puncture can be made with a cystitome and completed with a forceps. If poor visualization prevents CCC, then a canopener with several bites can be done and the liquid lens matter aspirated using a 25 G canula and the remaining nucleus is removed with an I/A or ultrasound handpiece. Canopener is then converted to CCC using a two stage procedure prior to IOL implantation.

**5.IOL implantation**

IOL is placed through a wound that is extended to the diameter of the optic chosen(5-7mm).One piece UV blocking PMMA IOLs with an overall diameter between 10.5-12mm and with an optic diameter between 5-6.5mm are required.Heparinised IOL s may be advantageous in decreasing the intense post operative inflammatory response often seen in paediatric population.

**5.Management of Posterior Capsule**

A planned primary posterior capsular opening can be made in children of less than 10 yrs of age to prevent secondary cataract or to remove a posterior

plaque. It can be done before or after placement of the IOL in the bag. Primary posterior capsulorrhexis can also be used as a method to prevent extension of a tear when a small linear or triangular PC rupture occurs inadvertently. It can be started using a cystitome or bent needle and completed with a Kelman McPherson capsulorrhexis forceps. Before the circular tissue of the posterior capsule is removed vitreous strands should be cut with a scissors and the end result should be a well centred posterior capsulorrhexis that is concentric and smaller than the CCC. Posterior capture of the IOL optic can be done after suturing the scleral wound under viscoelastic.

**6. Closure** should be with a continuous shoelace or a continuous and horizontal suture either absorbable or permanent suture 10-0 nylon and 7-0 polyglactin are most popular. Conjunctival closure may be with a running temporary absorbable or non absorbable suture.

***Postoperative Treatment***

Postoperatively a child's eye tends to react more than adults. Both in infants and children reaction does not appear until a day or two after surgery. Topical steroid antibiotic drops are used four times daily and pupil dilated with homatropine. Eye drops are gradually tapered off after four weeks and stopped. Suture removal is dome under general anaesthesia in 2-3 months. Amblyopia treatment should be started one week after surgery. Cycloplegia is continued for

one month to minimize fibrin deposition[34]. Since inflammation is more , they are advised more frequent follow ups[35].

Inadequate preoperative evaluation and postoperative treatment of amblyopia may limit the ultimate visual success in paediatric cataracts especially those involving ***monocular cataracts***[36-38]**.**

## Modes of Visual Rehabilitation in Pediatric Unilateral Aphakia

The prime aim is to prevent amblyopia due to visual deprivation and to provide binocular single vision as far as possible.

**1. Contact Lens:**

**Advantage:** Adjustable to compensate for the myopic shift of 9-15D in the first 4 yrs of life.

**Disadvantages:** Compliance rates are less and complications like keratitis, hypoxic ulceration, pannus and corneal edema can occur.

**2. Spectacle correction:**

It is very difficult in young children and has the disadvantage of magnifying the images in one eye.

**3. Intraocular lens:**

It is now the standard optical treatment but their use in infancy is still controversial and the hyperopic under correction to compensate for the myopic shift may cause anisometropia which may hinder the binocular single vision.

# COMPLICATIONS OF PAEDIATRIC CATARACT SURGERY AND MANAGEMENT

## INTRAOPERATIVE COMPLICATIONS

### 1. Globe collapse and positive pressure:

As the child's eye has less scleral rigidity more chances of globe collapse and postoperative shallow anterior chamber is more. This is countered by the use of viscoelastics throughout the surgery to maintain the anterior chamber depth and to protect the corneal endothelium.

### 2. Iris complications:

This includes pigment release, iris tears, dialysis, erosion and hyphema.

### 3. Posterior capsule rent and vitreous loss:

This can occur during lens cortical aspiration. It is managed by cutting the vitreous strands with automated vitrector or a mechanical vitrectomy and the IOL implantation is performed.

### 4.Hyphaema:

The sites of bleeding into the anterior chamber are corneoscleral wound, the iridectomy site and vascularised anterior synechiae. Air tapmonade and cautery will control the haemorrhage.

## POST OPERATIVE COMPLICATIONS

### 1.Postoperative uveitis:

Paediatric eyes are characterized by increased tissue reactivity especially when iris manipulation has been necessary during surgery. Postoperative anterior uveitis ( fibrinous and exudative ) is a commonly reported postoperative complication with pigment deposits on IOL and posterior synechiae formation. Frequent usage of topical steroids and even systemic steroids and heparin surface modified PMMA IOLs may reduce uveitis related complications[50]. Various methods have been devised to treat fibrinous exudates like intraocular streptokinase[51], recombinant tissue plasminogen activator[52], Nd:YAG laser discission and intraocular steroid[50].

### 2.Corneal Edema:

Transient corneal edema may occur in paediatrc cataract surgery but bullous keratopathy is a rare complication and studies have shown no significant loss of endothelial cells[53].

### 3.Wound leak:

As children often rub their eyes and play it may lead to trauma to the eye and wound leak.

**4.Endophthalmitis:**

Prevalence of postoperative endophthalmitis is 7 of 10,000 cases , after paediatric cataract surgery according to Wheeler and associates[54] and common organisms are Staphylococcus aureus,Staphylococcus epidermidis and Staphylococcus viridans. Important risk factors include nasolacrimal duct obstruction , periorbital eczema and upper respiratory tract infections. Techniques to avoid like topical antibiotic for 24 hours preoperative[54] and povidone iodine instillation in the eye at the time of surgery have been described.

**5.Capsular bag opacification:**

It includes anterior , posterior and equatorial capsular opacification and may lead to a decentration of the IOL. Posterior capsule opacification is amblyogenic if it occurs in the critical period of visual development in the younger children. Nd: YAG laser can be used for posterior capsulotomy if the PCO is not dense. But if dense thick PCO forms then surgical posterior capsulotomy with anterior vitrectomy may be required. Newer techniques of primary posterior capsulorrhexis with anterior vitrectomy has helped in maintaining a clear visual axis.

**6. Secondary membrane formation:**

Pupillary membranes can occur postoperatively regardless of whether IOL has been implanted or not. Vasavada and Trivedi[55] and Koch and Kohnen[56] recently reported formation of the secondary membrane over the anterior surface of the IOL surface after posterior CCC and optic capture procedure. Microphthalmic eyes with microcoria operated early in life are at greatest risk,especially if mydriatics or cycloplegics have not been used postoperatively. Early cases may be treated with Nd:YAG laser capsulotomy and severe cases need membranectomy and vitrectomy. The incidence of secondary membranes have decreased with “no iris touch” aspect of the closed chamber surgery and with use of topical corticosteroids and cycloplegics .

**7.Pupillary Capture**

Incidence of papillary capture after paediatric cataract surgery varies from 8.5% to 41%.[57,58].It occurs most commonly in children younger than 2yrs, when an optic size of less than 6mm is used and the lens is placed in the ciliary sulcus. Pandey and co workers reported an incidence of papillary capture as high as 40% in sulcus fixated IOLs whereas none of the eyes with in the bag IOL s showed this complication[57]. It can be left untreated but can cause decreased visual acuity, IOL malpositioning or glaucoma and surgical repair may be needed.

**8. Deposits on the IOL surface:**

Precipitates composed of pigments, inflammatory cells, fibrin and blood breakdown products are seen in the immediate postoperative period on the surface of the IOL. They are usually not visually significant. Heparin surface modified IOLs may reduce the incidence[53].

**9. IOL Decentration:**

Asymmetrical IOL fixation, inadequate capsular support or capsular fibrosis may lead to this complication. Capsular placement of the IOL and posterior capture has reduced the incidence of IOL decentration.

**10.Glaucoma:**

The incidence of glaucoma varies from 3% to 32%[59]. Although microphthalmic eyes appear to be at highest risk, cataract surgery before the age of 1 yr, congenital rubella and poorly dilated pupils are other risk factors. Glaucoma occurring soon after surgery usually is due to pupillary block or peripheral anterior synechiae which is uncommon in children. The reported mean interval from the time of cataract surgery to the development of glaucoma ranged from 6yrs to 56yrs[60]. The most common variety is open angle glaucoma.[50]. Asrani and Wilensky[59] recommended a screening examination every 3 months during the first postoperative year, twice yearly after that till the tenth year and annually thereafter for glaucoma. Medical treatment should be

tried first but a glaucoma filtering surgery with antimetabolites or a drainage implant may be necessary to control the IOP.

**11.Retinal Detachment:**

The incidence of retinal detachment following paediatric cataract surgery is reported between 1% to 1.5% and has declined with the refinement of surgical techniques and instruments. Significant risk factors include high myopia and repeated surgeries. The interval between cataract surgery and retinal detachment varied from 23 – 34 years according to some authors[61].

**12. Cystoid macular edema:**

It is a rare complication after paediatric cataract surgery probably due to the healthy retinal vasclulature.

**13. Residual refractive error:**

After implantation of IOL a small residual hypermetropic correction may be required. Significant late myopia is common as the years pass.

**14. Suture related complications:**

Mucous collection and vascularisation may be seen at the suture sites. This may be minimized by removing the sutures in 2-3 months time.

# VISUAL OUTCOME IN PAEDIATRIC CATARACT

**1. Visual acuity:**

The visual outcome of eyes with infantile cataract depends on many factors including the age of onset and the age of surgery, age at which optical correction was initiated and the degree with which the fellow eye is occluded[61-63]. Since it is very difficult to know precisely when a cataract developed and to quantify the density most authors evaluate visual outcomes in reference to the age at surgery and the compliance regarding optical and occlusion therapy.

# VISUAL OUTCOME IN UNILATERAL CATARACTS

The visual outcome of unilateral cataracts depend on many factors including the age of onset, age at surgery, age at which optical correction was initiated and the compliance to occlusion therapy. Since it is very difficult to know precisely when a cataract developed and to quantify the density most authors evaluate visual outcomes in reference to the age at surgery and the compliance regarding optical and occlusion therapy[61-63].

Visual outcomes of unilateral cataracts is better with intraocular lens than contact lens, however adherence to occlusion therapy is crucial. Good binocular function may be present in 10% of unilateral cataracts and may even allow stereopsis if treated early. Strabismus develops in 40-70% of children with cataracts, esotropia being more common in congenital cataracts. Presence of strabismus is also a factor influencing the final visual outcome[79].

# AIMS AND OBJECTIVES:

1. Analysis of visual outcome in unilateral congenital / developmental cataract in paediatric age group.

2. To document the

   i. Morphology

   ii. Aetiology

   iii. Associated systemic and ocular manifestations

3. To record the

   1. Axial length.
   2. Refractive error.
   3. Keratometry

      during the period of study and to compare the changes between the two eyes.

4. To analyse the factors influencing visual outcome

# MATERIALS AND METHODS

It is a prospective clinical study conducted in Aravind Eye Hospital for a period starting from June 2004 to February 2006. All children with unilateral cataract; both congenital and developmental cataract (between 0 and 15 years of age) were included in the study after informed consent and the children were followed up for a minimum of 6 months post operatively.

## Inclusion criteria:

1. Unilateral congenital /developmental cataract.
2. Age 0 – 15 years.
3. Extra capsular cataract extraction / IOL surgery (primary / secondary procedure).

## Exclusion criteria:

1. Informed consent not given.
2. Complicated cataracts/Traumatic cataracts.
3. Confirmed congenital rubella syndrome.
4. Mentally handicapped patients.
5. Congenital bilateral cataract.

**Preoperative Evaluation**

All the cases which were eligible according to the inclusion criteria were evaluated completely noting the age, and best corrected visual acuity with appropriate charts - either Snellens or Sheriden Gardiner's or Cardiff card according to the age and cooperation of the child or by asking them to pick up cake decoration (an approximate assessment of 6/24 vision or less was made). Anterior segment evaluation with a slit lamp, morphological classification of cataract and posterior segment evaluation with an indirect ophthalmoscope or ultrasound B scan depending on the clarity of media was done.

**Systemic evaluation**

Complete systemic evaluation was done preoperatively by the paediatrician or anaesthetist to rule out any associated cardiovascular, gastrointestinal, respiratory or central nervous system pathology.

**Investigations**

Routinely only blood haemoglobin and urine sugar were done, and in children less than 1yr of age a chest X-ray was also taken, mainly for anaesthesia clearance.

**Anaesthesia**

All the surgeries were performed under general anaesthesia with endotracheal intubation. After a fasting period of 6 hours for solids and 4 hours liquids anaesthesia premedication was given with intramuscular injection of atropine 0.02 mg/kg or glycopyrrolate 0.01mg/kg with midazolam 0.05-0.1mg/kg.

Induction of anaesthesia was with intravenous Propofol 2-2.5 mg/kg or pentothal sodium (4 mg/kg) followed by a non depolarising muscle relaxant of intravenous vecuronium 0.08-0.1mg/kg or atracurium 0.5mg/kg. Endotracheal intubation and inhalational anaesthesia with 33% oxygen and 77% nitrous oxide mixture with Sevoflurane 1% or Halothane 0.5-1% along with mechanical ventilation with Boyle's apparatus was done. Anaesthesia was maintained with intravenous Fentanyl 1-2 microgram /kg. Reversal of anaesthesia was with intravenous neostigmine 0.06-0.08mg/kg with atropine 0.02 mg/kg.

**Surgical procedure**

Preoperative pupillary dilatation is done with tropicamide eye drops. After draping the eye, superior rectus bridle suture is applied, fornix based conjunctival flap taken, superior sclerocorneal tunnel of 5-6mm (a or limbal incision) is made without sidepockets. Side-port is made at 9'o clock position in almost all cases and is used mainly to form the anterior chamber at the end of surgery. Curvilinear capsulorhexis of the anterior capsule is done initiated under viscoelastics with a cystitome and completed with a capsulorhexis forceps with a centrepetal force. Hydrodissection is done in all cases except posterior polar cataract and posterior lenticonus and the cortex is aspirated with a simcoe cannula or an irrigation aspiration probe. Primary posterior capsulorhexis was done in children less than 5 yrs before or after implantation of intraocular lens which is smaller then the anterior capsulorhexis. If it was done after implantation of the intraocular lens then an additional paracentesis was made at the 3'o clock position and lens lifted with a

cyclodialysis spatula. Viscoelastics are used when and where necessary. Anterior vitrectomy is done and intraocular lens is implanted in the bag and the tunnel is closed with one suture and sideport hydrated, superior rectus bridle is released and conjunctiva cauterised.

Postoperatively they received predisolone acetate 1% eye drops 6 times in a day and tobramycin eye drops four times till they were discharged and an antibiotic steroid eye ointment at night. Cyclopentolate eye drops was used once a day for 15 days in pseudophakia and atropine eye ointment once daily in aphakia. At discharge they were advised prednisolone acetate eye drops 6 times which was tapered over one month and tobramycin eye drops four times for one month. At 1 month review they were advised to taper or stop the antibiotic / steroid eye drops depending on the inflammation. The antibiotic steroid eye ointment is continued at night time till first follow up. They were advised to come for follow up at 1, 3, 6 months and then six monthly thereafter.

**IOL power calculation, axial length and keratometry recording**

Axial length was recorded with a sonomed A1500 model machine and keratometry with an ASCON Keratometer model ASK 999 or an Accuref 8001 Shin Nippon autorefractometer. If age was less than two years axial length was measured and intraocular lens implanted according to that. More than two years biometry was done (SRK- II formula) and undercorrected by 10%.

# RESULTS AND OBSERVATIONS

In our study a maximum of 45 patients were taken up of which 5 patients were lost to follow up and the remaining 40 patients were followed up for a minimum period of 6 months and a maximum of 18 months postoperatively (mean 8.35 months).

**1. Demographics**

**Table 1**

| Age at surgery (in years) | Frequency | Percentage |
|---|---|---|
| < 2 yrs | 10 | 25% |
| 2-5 yrs | 13 | 32.5% |
| 5-15 yrs | 17 | 42.5% |
| Total | 40 | 100% |

The largest number of children were in the age group 5-15 yrs (table 1).

**Table 2**

| Gender | Frequency | Percentage |
|---|---|---|
| Male | 23 | 57.5% |
| Female | 17 | 42.5% |

The number of male children were more by the order of 15% (table 2) in our study.

**2. Laterality**

**Table 3**

| Involved eye | Frequency | Percentage |
|---|---|---|
| Right eye | 12 | 30% |
| Left eye | 18 | 70% |

The left eye was more frequently involved than the right eye in our study.

**3. Presenting complaints**

**Table 4**

| Presenting complaints | Frequency | Percentage |
|---|---|---|
| Defective vision | 23 | 57.5% |
| White Reflex | 14 | 35% |
| Squinting | 12 | 30% |

**4. Morphology of cataract**

**Table 5**

| Morphology | Frequency | Percentage |
|---|---|---|
| Total cataract | 12 | 30% |
| Posterior lenticonus | 9 | 22.5% |
| Posterior polar cataract | 6 | 15% |
| Posterior sub capsular cataract | 5 | 12.5% |
| Lamellar cataract | 4 | 10% |
| Nuclear cataract | 2 | 5% |
| Anterior lenticonus | 1 | 2.5% |
| Pulverulent cataract | 1 | 2.5% |
| Total | 40 | 100% |

Table 4 shows the morphological patterns of the cataracts and total cataract amounts to 30% followed by posterior lenticonus and posterior polar cataract 15%.

**5. Presence of associated ocular Abnormalities**

**Table 6**

| Ocular finding | Frequency | Percentage |
|---|---|---|
| Strabismus | 14 | 35% |
| Microcornea | 2 | 5% |
| Nystagmus | 2 | 5% |
| Myopia | 1 | 2.5% |

13 of the patients did not have good fixation preoperatively, accounting upto 34.21% and postoperatively 9 of them did not have a good fixation accounting to 22.50%.

None of the patients in our study had any systemic association or other congenital anomalies.

**6. Family History**

12.5% of the children were born of consanguinous marriage. None of them had a family history of cataract.

**7. Age at Surgery and time delay in intervention**

In our study the minimum time interval between onset of symptoms and the surgery was 0.1 month and maximum was 108 months with a mean of 10.1 months (SD 18.87). Minimum age at surgery was 1.3 months and maximum 108 months with a mean of 62.5 months.

**8. Type of surgery performed**

**Table 7**

| | | **<2 yrs** | **2-5 yrs** | **5-15 yrs** | **Total** |
|---|---|---|---|---|---|
| ECCE | Frequency | - | 1* | - | 1 |
| | Percentage | - | 7.69% | - | 2.5% |
| ECCE + IOL | Frequency | - | 4 | 14 | 18 |
| | Percentage | - | 33.77% | 82.35 | 45% |
| ECCE + PPC + IOL | Frequency | 2 | 3 | 3 | 6 |
| | Percentage | 20% | 23.08% | 5.88% | 15% |
| ECCE + PPC + AV + IOL | Frequency | 3 | 4 | 2 | 9 |
| | Percentage | 30% | 30.77% | 11.6% | 22.5% |
| ECCE + PPC + AV | Frequency | 5 ♣ | 1 * | - | 6 |
| | Percentage | 50% | 7.69% | - | 15% |

Table 7 shows the type of surgery done which varies according to the age group and the level of co-operation expected if a YAG capsulotomy was required at a later date.

* No IOL was placed as they had microcomea

♣ One of these patients had a secondary IOL placed at 6 months of age

**9. Strabismus surgery**

**Table 8**

| | **< 2 yrs** | **2-5 yrs** | **5-15 yrs** | **Total** |
|---|---|---|---|---|
| Squint Surgery done | 2 | 4 | 2 | 8 |
| Percentage | 20% | 30.77% | 11.76% | 20% |

Of the total 8 children (20%) who underwent squint surgery along with cataract surgery 30.77% were in the age group of 2-5 yrs and 20% in the age group of < 2 yrs and the least was in the age interval of 5-15 yrs (11.76%).

**10. Post operative inflammation**

**Table 9**

| | **Frequency** | **Percentage** |
|---|---|---|
| Significant Postoperative inflammation | 5 | 12.5% |

12.5% of the children developed significant postoperative inflammation in the form of hypopyon or fibrin membrane.

**11. Axial length**

The mean preoperative axial length was 19.53mm in <2 yrs, 22.03mm in 2-5 yrs and 23.11mm in >5 yrs. The mean difference in the preoperative and postoperative axial length was found to be more in the < 2 yrs age group compared

with the other age groups with a mean difference of 0.3556 ± 0.4664mm in the operated and 0.8878 ± 0.70924mm in the normal eye.

**Table 10**

| Age group | Eye | | | | | |
|---|---|---|---|---|---|---|
| | Operated | | | Unoperated | | |
| | Mean Pre Operative (mm) | Mean Post Operative (mm) | Mean Difference (mm) | Mean Preoperative (mm) | Mean Post Operative (mm) | Mean Difference (mm) |
| < 2yrs | 19.5356 | 19.8911 | 0.3556 | 19.9011 | 20.7889 | 0.8898 |
| 2-5 yrs | 22.0364 | 22.1518 | .1155 | 21.9227 | 21.9927 | 0.0700 |
| > 5 yrs | 23.1188 | 23.1659 | 0.0471 | 23.0235 | 23.1241 | 0.1006 |

The change in operated eye was compared with that of the normal eye by Mann Whitney test and p value was 0.067 in < 2yrs group, 0.869 in 2-5 yrs age group and 0.460 in > 5yrs age, showing that there was no significant difference between the normal and operated eye with regard to axial length change.

At the time of surgery the mean axial length difference between the operated and the unoperated eye (interocular axial length difference) was 0.133 and postoperatively it was 0.1850.

## 12. Keratometry

**Table 11**

| | Operated | | | Unoperated | | |
|---|---|---|---|---|---|---|
| | **Pre Operative (D)** | **Post Operative (D)** | **Mean Difference** | **Pre Operative (D)** | **Post Operative (D)** | **Mean Difference** |
| 2-5 yrs | 42.5 | 42.02 | 0.47 | 42.56 | 42.43 | 0.1236 |
| > 5 yrs | 43.21 | 43.54 | 0.33 | 43.46 | 43.11 | 0.2417 |

In our study the mean preoperative & postoperative readings in the operated eye was 42.5D and 42.02D respectively and 42.56D & 42.43D in the unoperated eye in the 2-5yrs age group. In the 5-15 yrs mean preoperative Kreading was 43.21 and postoperative was 43.54 in the operated and it was 43.46 and 43.71 at the last follow up.

There was flattening of the corneal curvature during the follow up in the 2-5 yrs age group compared with the 5-15 yrs age group. But there was no significant difference in the corneal curvature change between the operated and the unoperated eye (Mann. Whitney test p value > 0.05).

## 13. Visual Acuity Improvement

Visual acuity improvement of one Snellen line or improvement in fixation pattern was considered as improvement. The following table shows the improvement in different age groups.

**Table 12**

| | **Improved** | | **Stayed same** | |
|---|---|---|---|---|
| | **Frequency** | **Percentage** | **Frequency** | **Percentage** |
| < 2 yrs | 7 | 70% | 3 | 30% |
| 2-5 yrs | 7 | 53.85% | 6 | 46.15% |
| 5-15 yrs | 18 | 90% | 2 | 10% |

## 14. Influence of associated ocular abnormalities

**Table 13**

| | **Visual Improvement** | | **P value** |
|---|---|---|---|
| Pre operative Strabismus | Present<br>Absent | 64.3%<br>76.9% | 0.393 |
| Nystagmus | No improvement | | 0.018 |
| Microcornea | | | 0.018 |
| Pre operative Fixation | Good<br>Poor | 83.3%<br>50% | 0.029 |

Table 13 shows that when there was preoperative strabismus only 64.3% showed visual improvement whereas 76.9% of the children without preoperative strabismus showed visual improvement.

Similarly when preoperative fixation was good 83.3% showed visual improvement whereas the proportion of children with visual improvement dropped to 50% when fixation was poor. None of the children with Nystagmus or microcornea had improvement in vision and three of these factors had a statistically significant association (Chi square test p-value < 0.05).

The morphology of the cataract however did not have any significant association with the visual outcome Chi square tests p-value 0.322 (> 0.05).

**15. Influence of type of surgery on visual outcome**

**Table 14**

| Type of surgery | Improved | Not Improved |
|---|---|---|
| ECCE | | 100% |
| ECCE + PPC + AV | 50% | 50% |
| ECCE + IOL | 77.8% | 22.2% |
| ECCE + PPC + IOL | 100% | |
| ECCE + PPC + AV + IOL | 66.7% | 33.3% |

Patients in whom IOL was implanted showed a better visual outcome than those without IOL, though the association of type of surgery with outcome was not statically significant.

**16. Posterior capsular opacification**

Four of our patients developed posterior capsular opacity of which 2 underwent YAG capsulotomy and 2 patients underwent surgical membranectomy. Three of the patients were 2 years and less and developed posterior capsular opacity within 5-6 months of surgery. Only one patient above 5 yrs developed posterior capsular opacity after 1 year of surgery. All of them had improvement in vision.

**17. Final visual outcome in children >2 yrs**

In the age groups 2-5 yrs and > 5 yrs when visual acuity was assessed a final outcome of ≥ 6/18 Snellen and Snellen equivalent was obtained in 71.4% and 33.3% respectively.

**Table 15**

| **Final Visual acuity in improved cases** | **2-5 yrs** | **5-15 yrs** | **Total** |
|---|---|---|---|
| ≥ 6-18 | 71.4% | 33.3% | 45.5% |
| 6/24 – 6/60 | - | 33.3% | 22.7% |
| < 6/60 | 28.6% | 33.3% | 31.8% |

**18. Type of IOL**

In our study we used the following types of IOLs.

1. Single piece equiconvex PMMA lens with C haptic design (5.5mm optic, 5mm optic).

2. Single piece equiconvex PMMA lens with C haptic 6mm optic.
3. Three piece biconvex PMMA lens with C haptic 6mm optic.
4. Single piece acrylic lens with stable force haptic design 6mm optic.

The choice of material of IOL was also discussed with the parents and hence also depended on the affordability of our patients.

**19. Factors influencing visual outcome**

Evaluating the final visual acuity in the above said groups and comparing it with the various preoperative and postoperative parameters the following results were obtained.

**1. Strabismus**: 40% of children with strabismus had visual acuity ≥ 6/18 whereas 47.1% of those who did not have strabismus improved to ≥ 6/18

**Table 16**

| Visual acuity | Percentage |
|---|---|
| ≥ 6-18 | 40% |
| 6/24 – 6/60 | 20% |
| < 6/60 | 40% |

**2. Nystagmus:** None of them improved. All had vision < 6/60

**3. Time interval** between onset of symptoms and surgery was compared with visual outcome.

**Table 17**

| | 0-4 Months | 4-8 months | 8-12 months | > 12 months |
|---|---|---|---|---|
| ≥ 6-18 | 70% | 10% | 10% | 10% |
| 6/24 – 6/60 | 40% | 40% | 20% | - |
| < 6/60 | 28.6% | 14.3% | 14.3% | 42.9% |

It was found that lesser the time interval better was the visual outcome. In <2 yrs age group also the some pattern was seen with 71.4% having visual improvement if the time duration was <4months and only 50% having visual improvement when the duration was >8months.

**4. Morphology of cataract**

83.3% of Total cataracts
50% of posterior polar cataract
33.3% of posterior lenticonus
66.7% of posterior subcapsular cataract
Pulverulent cataract (only 1 case <6/60)

} Improved to ≥ 6/ 18

Lamellar cataracts - 50% had vision 6 /24 – 6/60 group and 50% < 6/60. But there was no statistically significant association with the type of cataract and the visual outcome.

**5. Type of Surgery**

**Table 18**

| | | ECCE IOL | ECCE + PPC + IOL | ECCE + PPC + AV + IOL |
|---|---|---|---|---|
| ≥ 6 / 18 | Frequency | 5 | 3 | 2 |
| | Percentage | 35.7% | 75% | 50% |
| 6 / 24 6/60 | Frequency | 4 | 1 | |
| | Percentage | 28.6% | 25% | |
| <6/60 | Frequency | 14 | 4 | 4 |
| | Percentage | 35.7% | - | 50% |

**6. Amblyopia management** was instituted for 25 of our patients and 16 of them (64%) showed improvement. 9 of them (36%) did not show any improvement. Of the improved cases 30% had visual acuity ≥6/18 and 30% had 6/24 – 6/60 visual acuity and 40% had visual acuity of < 6/60.

**7. Binocular single vision** was checked for 19 of our patients and it was present in 36.8% and absent in 63.2%.

# DISCUSSION

Morphological pattern observation in our study shows a preponderance of total cataract, posterior lenticonus and posterior polar cataracts than other types. 22.5% of our patients had posterior lenticonus compared to 18% in the study conducted by **Hiles et al[5].** 47.5% of the children in our study had associated ocular abnormalities which is comparable to the observation of **Rahi et al[77]** which was 47%. Preoperative strabismus was seen in 35% of the children in our study which almost parallels the observation of **France TD et al[81]** (30%).

No systemic association was found in our study which agrees with the previous studies that unilateral cataracts are mostly idiopathic [69].

Regarding the final visual outcome, our study has 45.5% patients with visual acuity of 6/18 or better as compared to 53% of children improving to 20/80 or more in a study conducted by **Eileen Birch et al[80]** which is almost parallel. Even though 70% of children in our study in the age group of less than two years had improvement, longer follow up is needed for assessing the final visual outcome. But this short term improvement also indicates that there is potential for good visual outcome if operated at a young age even in unilateral cataract.

The earliest age of intraocular lens implantation in the study of early treatment of unilateral congenital cataracts **(Cheng et al[37])** was 5.2 weeks and in our study was 6 months which was a secondary IOL for a child who had ECCE + PPC + AV and squint surgery at 3 months. He improved from poor fixation in the

preoperative evaluation to a vision of being able to pick up cake decoration at the last follow up. It was seen that visual improvement was seen more in children receiving IOL compared to those who did not and 45.5% of the cases having visual acuity ≥6/18 received intraocular lens. Intraocular lens was implanted in 5 children (50%) of age < 2 yrs and all of them showed improvement in fixation pattern and 4 of them were able to pick up cake decoration uniocularly.

This shows that intraocular lens appears to be a safe and effective alternative to contact lens or spectacle correction of unilateral aphakia in children < 2yrs of age and may aid in reducing amblyopia which is in concordance with **Amy K. Hutchinson et al[82]** in their study. But the confounding factor is the inability to determine the age of onset of cataract, as inclusion of patients who acquired their lens opacification at any time other than prenatally would skew the results towards a better visual outcome **(Cheng et al[37]).**

However surgery is not the sole determinant of a satisfactory visual outcome. Other factors which we have come across which blunts the visual improvement are the associated anterior segment abnormalities like microcomea, presence of Nystagmus, strabismus, time interval from onset of symptoms to cataract surgery and postoperative management strategies like amblyopia management. Associated ocular abnormalities like microcornea, Nystagmus and poor fixation are associated with poor visual outcome and they had a statistically significant association. In the presence of strabismus 40% improved to ≥6/18 and the results were similar to those obtained by **Cheng et al[37]** suggesting that

preoperative strabismus is a predictive factor for final visual outcome. Our study also showed that ***lesser the interval*** between onset of symptoms and surgery better the visual outcome. The incidence of postoperative complications was very less in our study and only 5 patients having significant postoperative inflammation in the form of fibrin membrane or hypopyon which points towards the improvement of surgical techniques compared to previous studies.

Secondary surgeries were as high as 47% in the study conducted by **David Hiles**[5] whereas it was only 2 YAG capsulotomies and 2 surgical membranectomies in our study but longer follow up is definitely required for commenting about this. 64% (16 out of 25) of the patients who received amblyopia management on the whole and 3 of them above two years of age even obtained a visual acuity of 6/18 or better.

The mean preoperative axial length of the operated eye in the age groups <2 yrs, 2-5 yrs and 5-15 yrs were 19.53mm, 22.03mm and 23.11mm respectively compared to the mean axial length of 18.46mm in the congenital group (onset < 1 yr) and 21.7mm in the developmental (onset > 1 yr) in the study of **Flitcroft et al**[83]. The minimal difference in the mean value can be attributed to the wider interval of age group in our study.

The mean change in axial length during the follow up in the operated eye was 0.35mm in <2 yrs of age compared to a change ranging from 0.91 - 8.01mm (mean 3.41mm) in the study by **Flitcroft et al**[83] in the congenital cataract group. In the 2-5yrs age group the mean axial length change was 0.11mm and in the 5-15

yrs age group it was 0.047 mm compared to a mean change of 0.37mm in the study by **Flitcroft et al.** However, the pattern of axial length difference agrees with the study of **Gordon and Donzis**[84] that the greatest increase in axial length occurs in the youngest age groups. We had keratometry readings available only for children more than 2 yrs and in none of them there was a significant difference over the follow up period which is in concordance with the observation of **Gordon and Donzis** that there is no significant change above one year of age.

The interocular axial length difference in our study at the time of surgery was 0.0133mm ±1.14 compared to the mean interocular axial length difference in unilateral cataracts which was observed by **Lal et al**[85] and was not statistically significant in our study but was in their study. The significance may be attributed to the larger sample size they had.

The axial length change of the operated eye over the period of study was compared with that of the unoperated eye which showed no significant difference. The same result was obtained with respect to keratometry changes and both of these were in agreement with the studies conducted by **Inatomi et al**[76].

The percentage of children improving in vision was 53.85% in the 2-5 yrs age group whereas it was 90% in the age group of 5-15 yrs.

Four of our patients developed posterior capsular opacity of which three were 2 yrs and less. Two of them underwent YAG capsulotomy under sedation and two patients underwent surgical membrancectomy. One of these patients underwent a primary procedure of ECCE with IOL without a primary posterior

capsulorhexis, one underwent posterior capsulorhexis but no anterior vitrectomy and only one patient developed a fibrous PCO after both primary posterior capsulorhexis and anterior vitrectomy. All patients developed PCO within 3-6 months of surgery. Only one patient above 5 yrs developed PCO after 1 yr of surgery. This points to the reasoning that in children especially <5 yrs the posterior capsule and the anterior vitreous face act as scaffold for PCO and not only posterior capsulorhexis but also anterior vitrectomy is essential to prevent PCO formation as is described in the study of **Koch et al**[56] and the duration of development of PCO also coincides with the duration they have observed

# CONCLUSION

1. Intraocular lens insertion in unilateral cataract gives a better prognosis in visual rehabilitation and is easier for initiating amblyopia management than glasses.
2. Use of intraocular lens in young children is relatively safe if there is correct case selection, proper techniques and timely intervention.
3. More than the unilateral nature the associated preoperative peroperative and postoperative factors influence the visual outcome like strabismus, type of surgery, amblyopia management and timely additional intervention.
4. The most common morphological pattern noticed were total cataracts and posterior lenticonus.
5. Unilateral cataracts tend to be mostly idiopathic.
6. Interocular axial length difference at surgery was not significant and there was no difference in axial length growth or keratometry changes between the affected and normal eye.
7. The maximum axial length growth over the follow up period was in the less than 2 yrs age group.
8. Continued follow up of paediatric IOL patients will address concerns of long term safety.

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84. Robert A. Gordon, Paul B Donzis Refractive development of the Human eye Archives of Ophthalmology Vol 103, June 1985.

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# PROFORMA

**Name of child** :
**Age:**
**Sex : M / F**
**Hospital number:**

**Study no:**
**Date of Admission:**
**Date of Surgery:**
**Date of Discharge:**

---

**Diagnosis:**

---

**PRESENTING COMPLAINTS:**

**1. Defective vision:** Yes/No
Laterality: RE/LE
Age of onset :
Duration:
Associated complaints

**2.White reflex :** Yes/No
Laterality:RE/LE
Duration:

3.Squinting:Yes/No
Duration:
4.Nystagmus: Yes/No
Duration:

**ANTENATAL HISTORY**

1.Mother's age : 2.Father's age:

2.History of:
a) fever: Yes/No Trimester: first/second/third
Rash: Yes/No
Treatment taken:

b) Nutritional deficiency:Yes/No

3. Any other medication taken :Yes/No Trimester:first/second/third
Drug and duration:

4. Radiation exposure:Yes/No  Trimester:first/second/third

**BIRTH HISTORY**

1.Born of consanguinous marriage: Yes/No.
If yes ,degree of consanguinity:
2.Preterm/full term/post term delivery
3.Hospital /Home delivery
4.Normal delivery/LSCS/Assisted delivery(forceps/vacuum extraction)
5.Birth weight:
6.Cried at birth:Yes/No.
7.APGAR scale (if available)

**POSTNATAL HISTORY:**

1.Use of oxygen/use of incubator
2.Fever/Jaundice/Seizure/Asthma/Cardiac/Others.
If present what medications are given.

3.Milestones:Normal/Delayed
4.Physical abnormalities:Yes/No
If yes describe:

**FAMILY HISTORY**
1.History of similar illness in family: Yes/No.

**PEDIGREE**

**GENERAL EXAMINATION**:

- Healthy/Sick baby
- Systemic illness-cardiovascular/respiratory/central nervous system/skeletal anomaly/deafness/muteness
- If yes, describe:

Any treatment taken for the same:

**OCULAR EXAMINATION:**

| | Right eye | Left eye |
|---|---|---|
| Fixation: | | |
| Visual acuity: | | |
| Refraction: | | |
| Sphere: | | |
| Cylinder: | | |
| Spherical equivalent: | | |
| Corrected acuity: | | |
| Nystagmus: | | |
| Strabismus: | | |
| Ocular movements: | | |
| Ant. segment findings: | | |
| Morphology of cataract: ☐ (1.nuclear 2.total 3.lamellar 4.sutural 5.membraneous 6.posterior polar 7.anterior polar 8.posterior lenticonus 9.anterior lenticonus ) | | |
| Intraocular pressure: | | |
| Axial length: | | |
| Keratometry reading: | | |
| Posterior segment findings: | | |

## **Peroperative parameters**:

Age at surgery:

Time interval between the time of detection and cataract surgery:

Type of surgery: ECCE with IOL / Lensectomy

Primary posterior capsulorhexis done: Yes / No

Anterior vitrectomy done :Yes/No

IOL power calculated (predicted ):

Power of IOL implanted:

Peroperative PCO:

## **Operative Complications**:

Unplanned aphakia:

Additional sutures:

Others:

## **Immediate postoperative data**:

Inflammation : ☐ 1.Fibrin membrane 2.Hypopyon.

Immediate postoperative PCO:

Treatment given :

## **FOLLOW UP**

Follow up: (1 months / 3 months / 6 months / 12 months / 18 months )

Age of child (in months): Date:

| | Right eye | Left eye |
|---|---|---|

Visual acuity

Refraction :
- Sphere:
- Cylinder:
- Spherical equivalent:

Predicted error at time of implant:

Corrected acuity:

Fixation:

Nystagmus:

Strabismus:

Axial length:

Keratometry reading:

Intraocular pressure:

Ant. segment findings:

Post. capsular opacity:

Anterior capsular opacification :Yes/No

Capsular phimosis: Yes/No

Fibrin membrane: Yes/No

Post. segment findings:

## Additional surgery

Surgical membranectomy: RE/LE Date:

Squint surgery:
RE/LE

Date:
Procedure done:

## Additional intervention

Yag capsulotomy : RE/LE Date:

Yag membranolysis: Yes/No Date:

Amblyopia management

## Spectacle compliance:

1. Hours worn per day :
2. Used for reading only: yes / no

## Stereopsis:

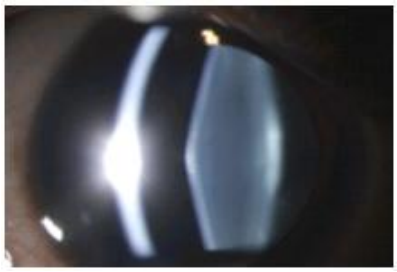
Binocular single vision grade: yes / no

# ABBREVIATIONS

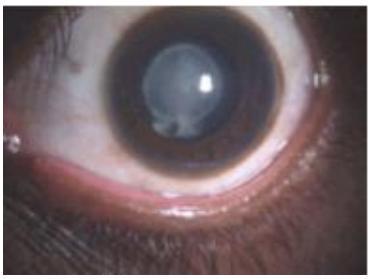
| | | |
|---|---|---|
| 1) IOL | - | Intra Ocular Lens |
| 2) PCO | - | Posterior Capsular Opacity |
| 3) PMMA | - | Poly Methyl Metha Acrylate |
| 4) ECCE | - | Extra Capsular Cataract Extraction |
| 5) PPC | - | Primary Posterior Capsulorhexis |
| 6) AV | - | Anterior Vitrectomy |
| 7) PHPV | - | Persistent Hyperplastic Primary Vitreous |
| 8) RP | - | Retinitis Pigmentosa |
| 9) VEP | - | Visual Evoked Potential |
| 10) TORCH | - | Toxoplasma Rubella Cytomegalovirus Herpes |
| 11) NdYAG | - | Neodymium Yttrium Aluminum Garnet. |

**UNILATERAL CONGENITAL CATARACT IN LEFT EYE**

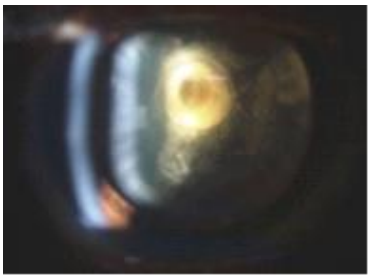
**UNILATERAL DEVELOPMENTAL CATARACT WITH EXOTROPIA IN RIGHT EYE**



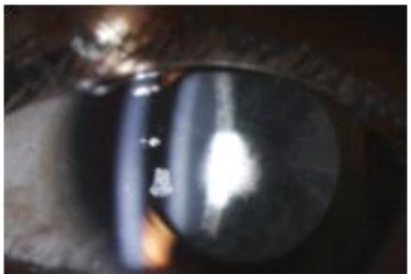
**ANTERIOR LENTICONUS**



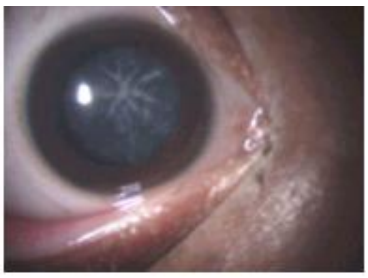
**LAMELLAR CATARACT**



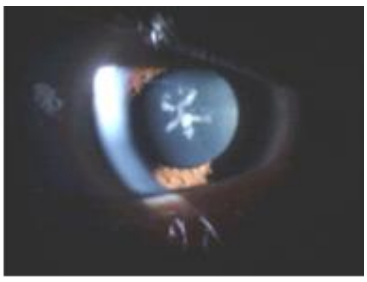
**POSTERIOR POLAR CATARACT**



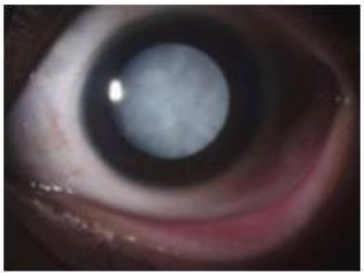
**POSTERIOR SUBCAPSULAR CATARACT**



**SUTURAL AND BLUE DOT CATARACT**



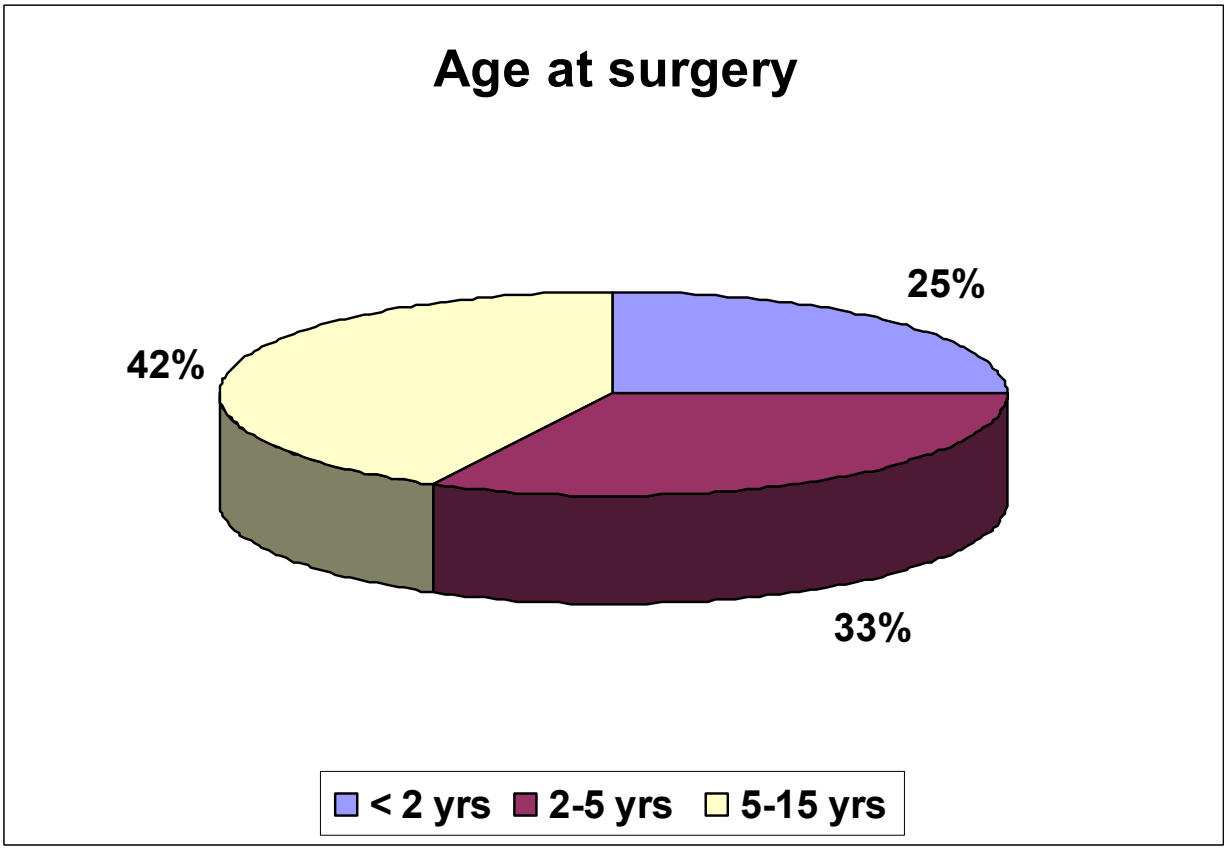
**SUTURAL CATARACT**

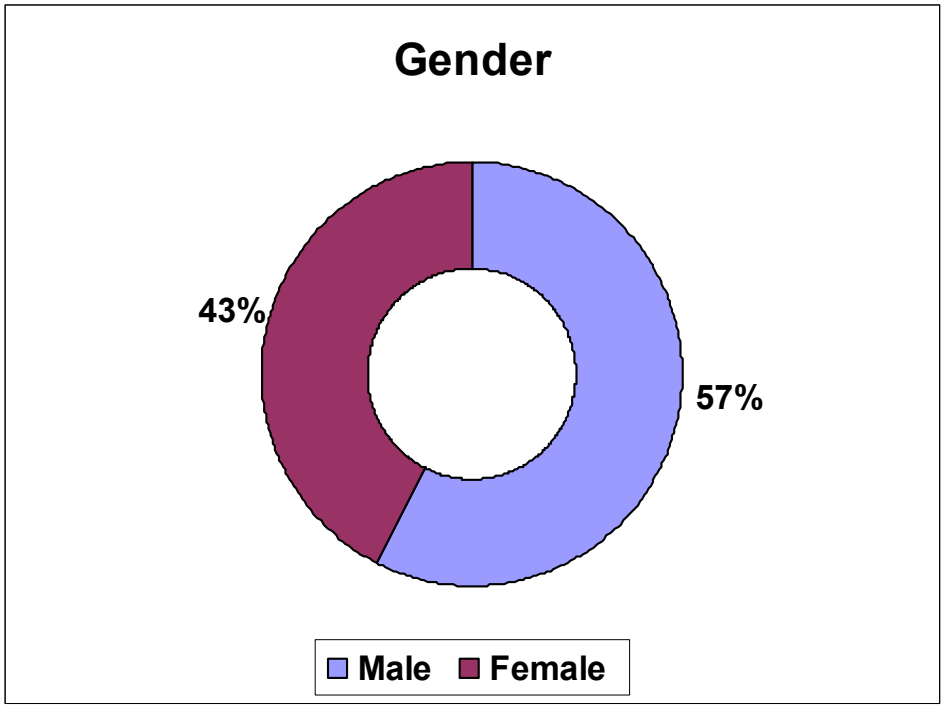


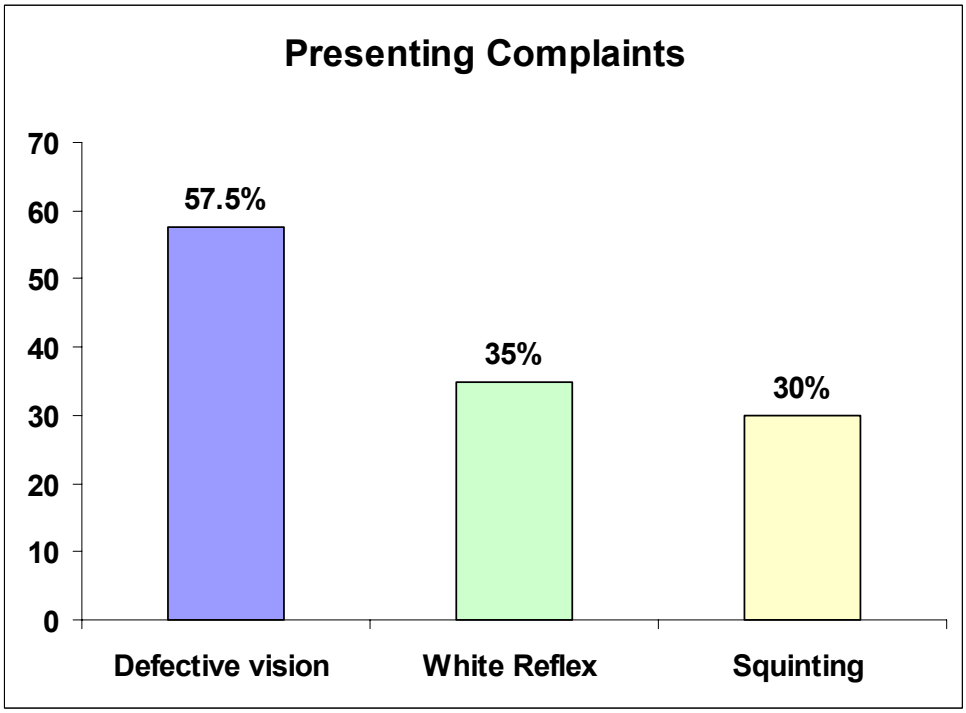
**TOTAL CATARACT**

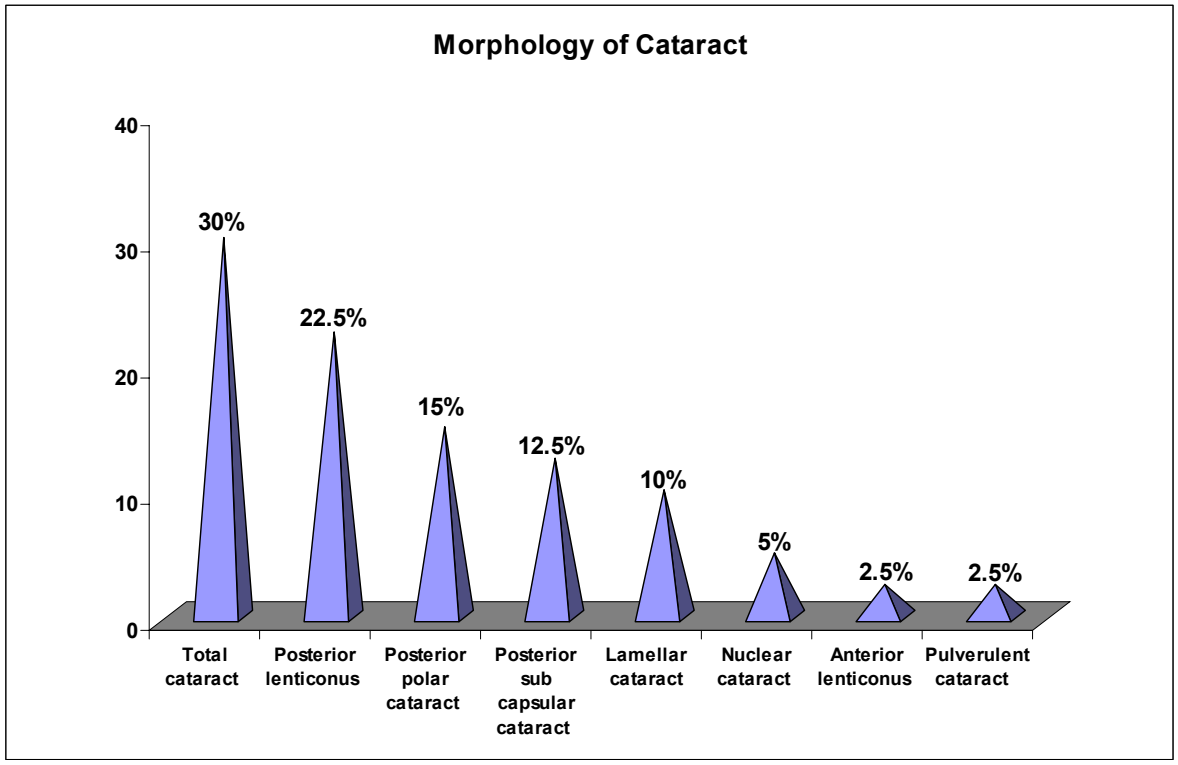
**INTRAOCULAR LENS IMPLANTED IN THE BAG**

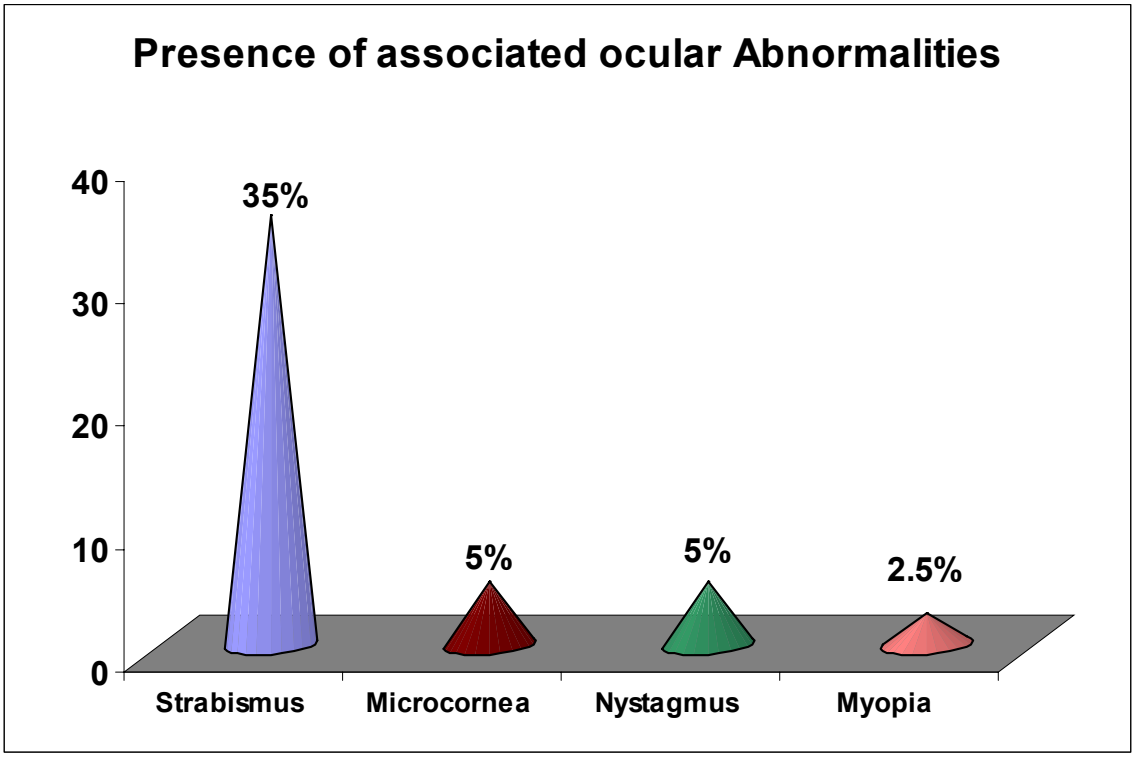
**PATCHING THE EYE -MODALITY OF AMBLYOPIA MANAGEMENT POSTOPERATIVELY.P**

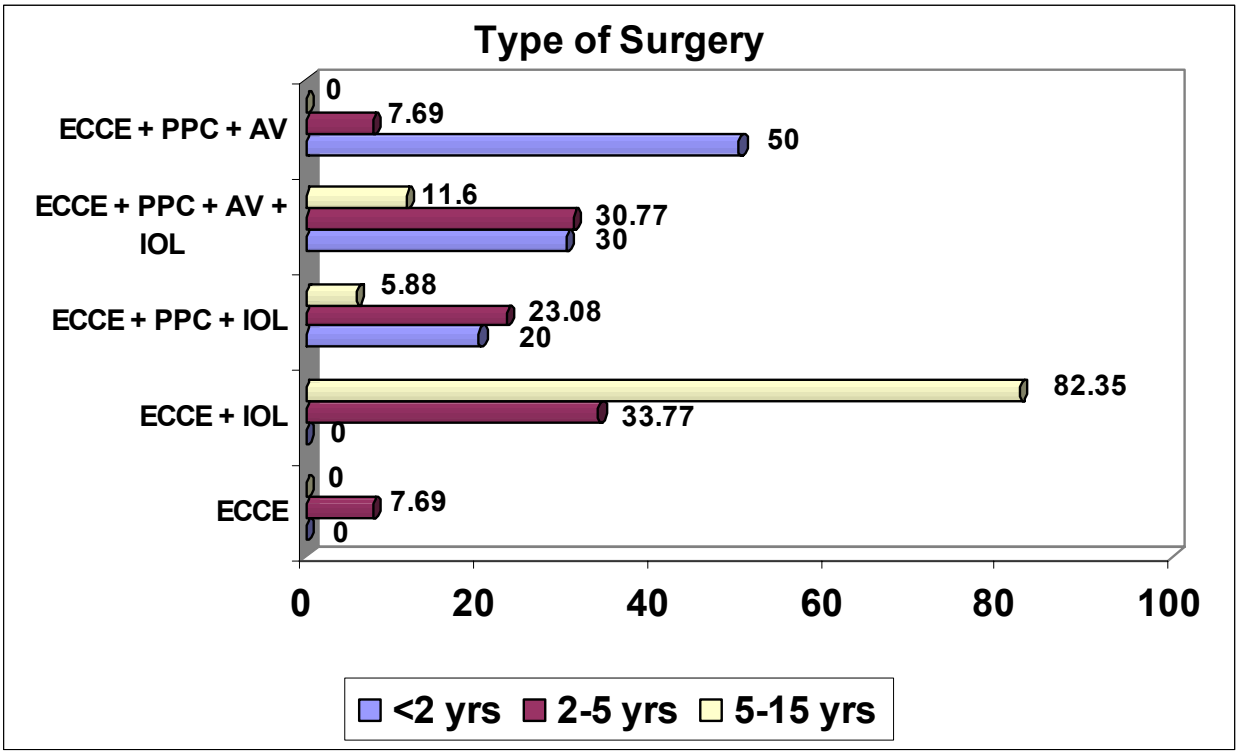

Age at surgery
25%
42%
33%
< 2 yrs
2-5 yrs
5-15 yrs

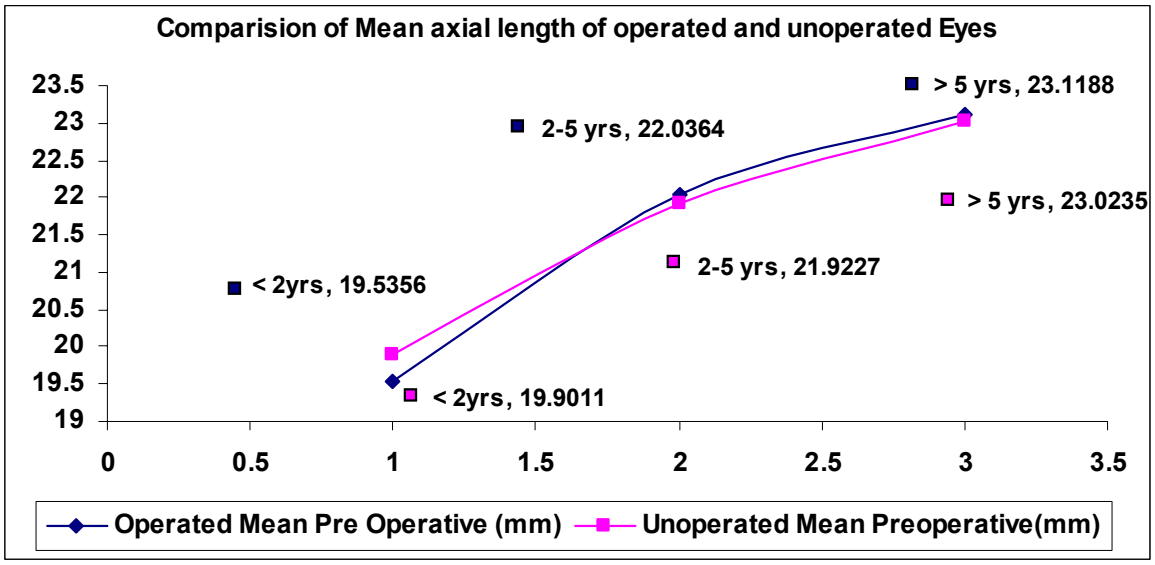

Gender
43%
57%
Male
Female

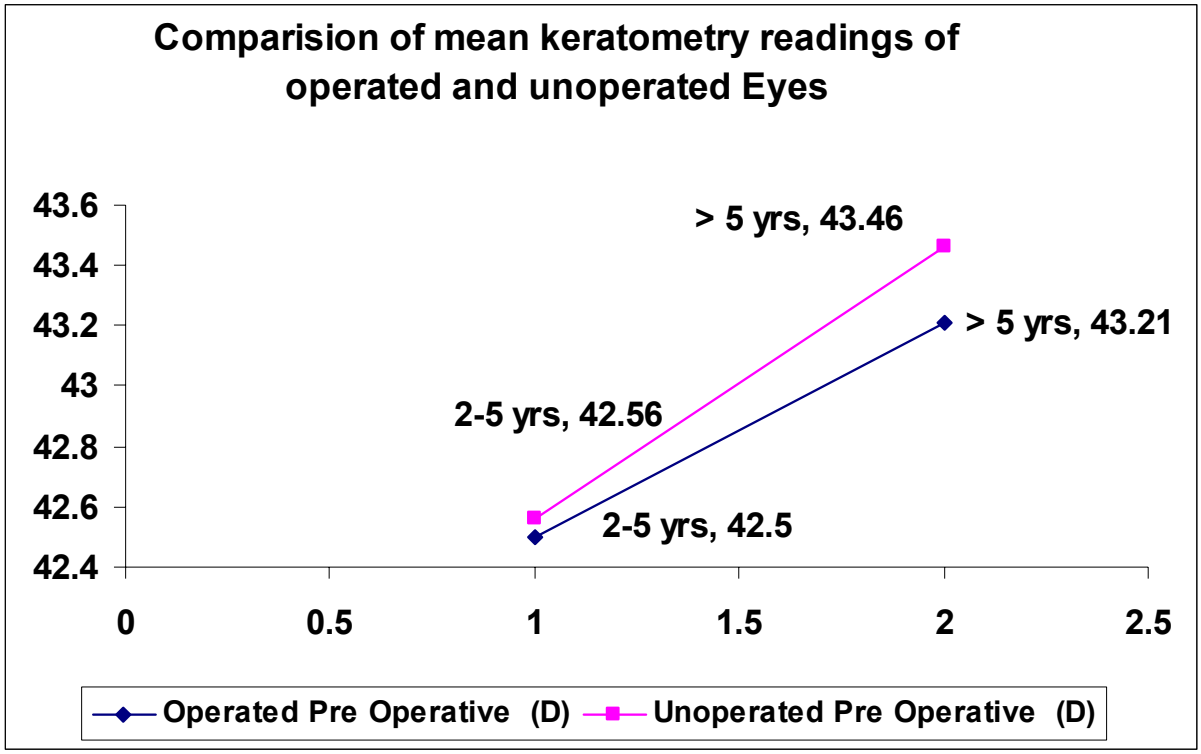

Presenting Complaints
70
60
50
40
30
20
10
0
57.5%
35%
30%
Defective vision
White Reflex
Squinting

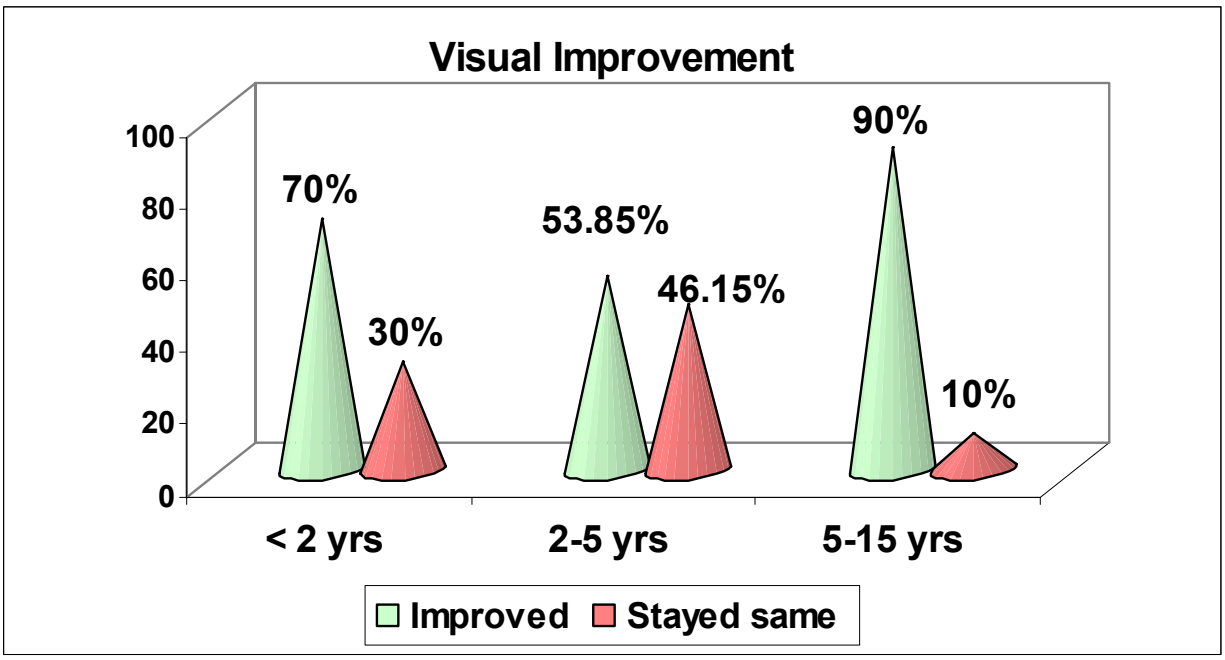

Morphology of Cataract
40
30
20
10
0
30%
22.5%
15%
12.5%
10%
5%
2.5%
2.5%
Total cataract
Posterior lenticonus
Posterior polar cataract
Posterior sub capsular cataract
Lamellar cataract
Nuclear cataract
Anterior lenticonus
Pulverulent cataract

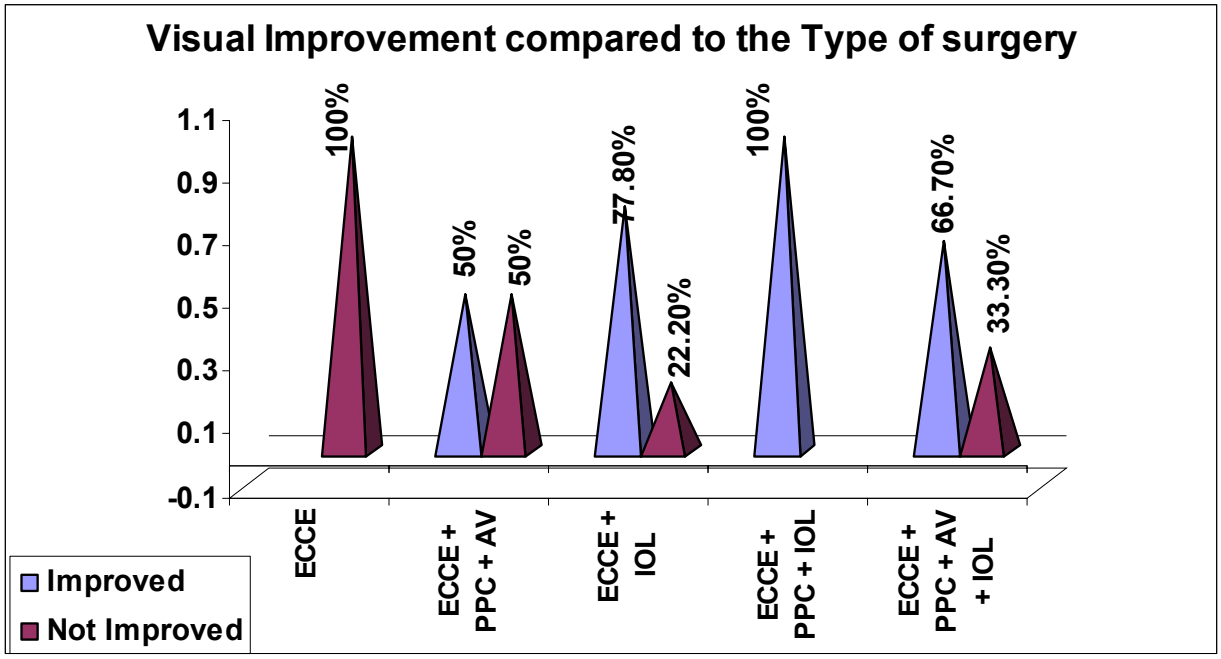

Presence of associated ocular Abnormalities
40
30
20
10
0
35%
5%
5%
2.5%
Strabismus
Microcornea
Nystagmus
Myopia

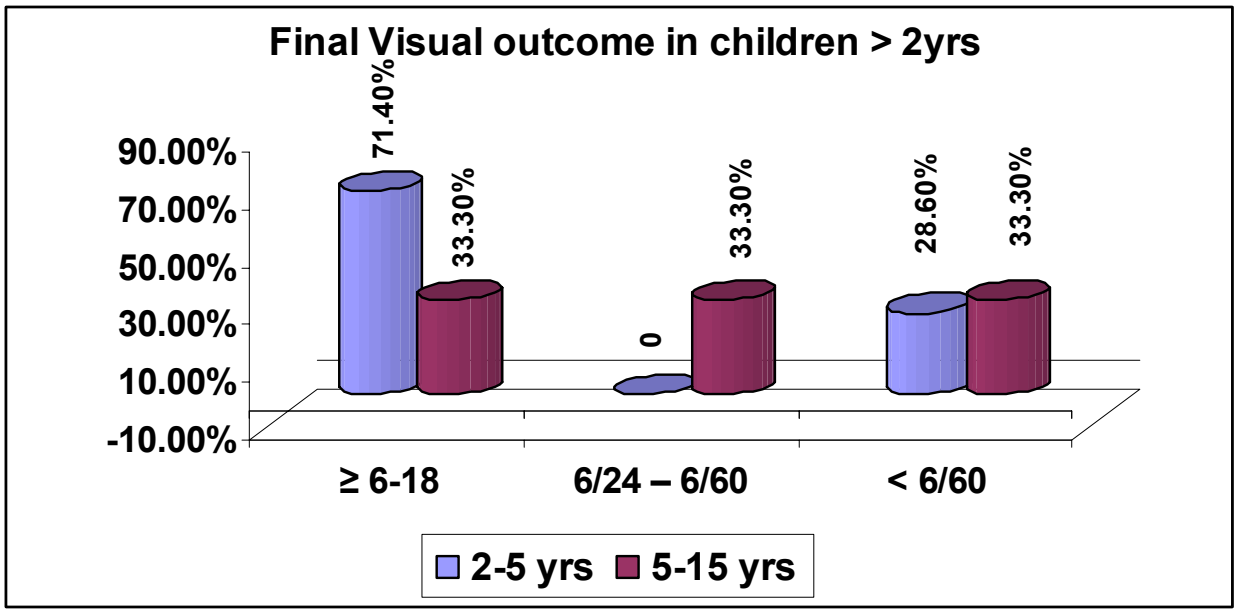

Type of Surgery
ECCE + PPC + AV
ECCE + PPC + AV + IOL
ECCE + PPC + IOL
ECCE + IOL
ECCE
0
7.69
50
11.6
30.77
30
5.88
23.08
20
82.35
33.77
0
0
7.69
0
0
20
40
60
80
100
<2 yrs
2-5 yrs
5-15 yrs

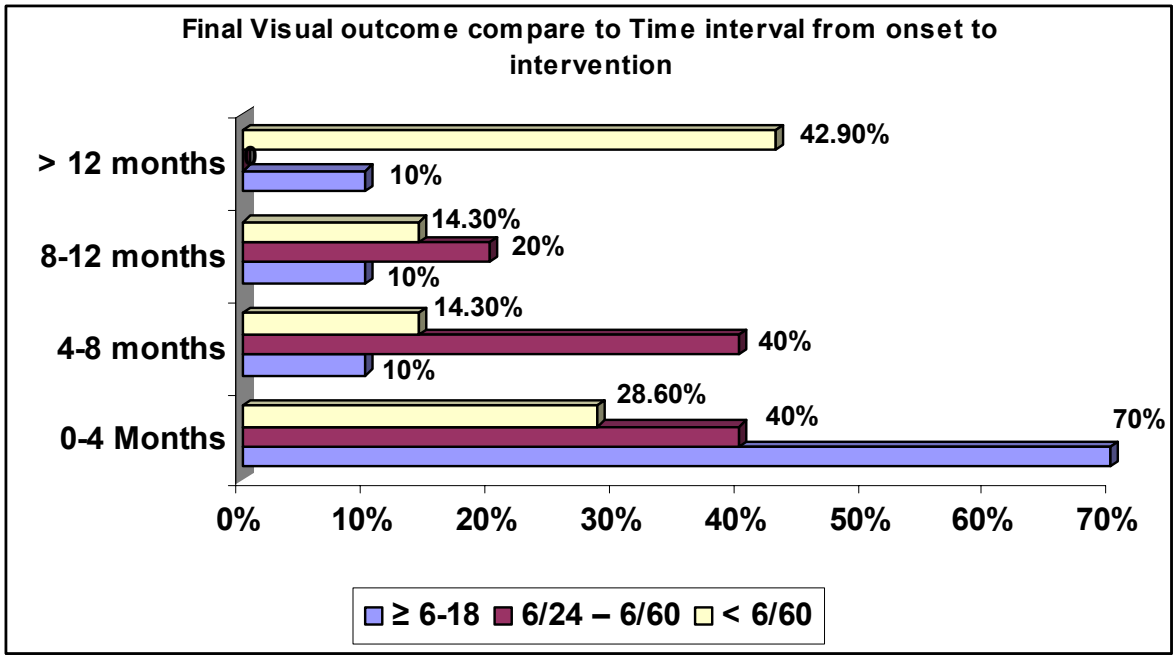

Comparision of Mean axial length of operated and unoperated Eyes
23.5
23
22.5
22
21.5
21
20.5
20
19.5
19
0
0.5
1
1.5
2
2.5
3
3.5
> 5 yrs, 23.1188
2-5 yrs, 22.0364
> 5 yrs, 23.0235
2-5 yrs, 21.9227
< 2yrs, 19.5356
< 2yrs, 19.9011
Operated Mean Pre Operative (mm)
Unoperated Mean Preoperative(mm)


Comparision of mean keratometry readings of operated and unoperated Eyes
43.6
43.4
43.2
43
42.8
42.6
42.4
0
0.5
1
1.5
2
2.5
> 5 yrs, 43.46
> 5 yrs, 43.21
2-5 yrs, 42.56
2-5 yrs, 42.5
Operated Pre Operative (D)
Unoperated Pre Operative (D)


Visual Improvement
100
80
60
40
20
0
70%
30%
53.85%
46.15%
90%
10%
< 2 yrs
2-5 yrs
5-15 yrs
Improved
Stayed same


Visual Improvement compared to the Type of surgery
1.1
0.9
0.7
0.5
0.3
0.1
-0.1
100%
50%
50%
77.80%
22.20%
100%
66.70%
33.30%
ECCE
ECCE + PPC + AV
ECCE + IOL
ECCE + PPC + IOL
ECCE + PPC + AV + IOL
Improved
Not Improved


Final Visual outcome in children > 2yrs
90.00%
70.00%
50.00%
30.00%
10.00%
-10.00%
71.40%
33.30%
0
33.30%
28.60%
33.30%
≥ 6-18
6/24 – 6/60
< 6/60
2-5 yrs
5-15 yrs


Final Visual outcome compare to Time interval from onset to intervention
> 12 months
8-12 months
4-8 months
0-4 Months
42.90%
10%
14.30%
20%
10%
14.30%
40%
10%
28.60%
40%
70%
0%
10%
20%
30%
40%
50%
60%
70%
≥ 6-18
6/24 – 6/60
< 6/60

| NAME | AGE | AGE1 | EX | HNO | DOS | PRECO M1 | LATER | FIXARE | FIXALE | VARE | VALE | BCVARE | BCVALE | NYSTAG | STRAINE | ANTSEG | MORPHO | IOPRE | IOPLE | AXIARE | AXIALE | K1RE | K2RE | K1LE | K2LE | POSTRE | POSTLE | AGESUR | SURAGE | TIMEINT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ponni | .25 | 3.00 | 2 | 2081471 | 13/08/05 | 2 | 2 | 2 | 2 | | | | | 1 | 2.00 | 1 | 2 | | | 19.27 | 19.28 | | | | | 1 | 1 | 3mths | 3.00 | 3.00 |
| Joel.R.Tharakan | .25 | 3.00 | 1 | 2050376 | 8/4/2005 | 3 | 1 | 2 | 1 | | | | | 2 | 1.00 | 1 | 8 | | | 18.01 | 18.82 | | | | | 1 | 1 | 3mths | 3.00 | .50 |
| Sanjeev Mithran | .15 | 1.80 | 1 | 1988114 | 26/10/200 | 2 | 1 | 3 | 3 | | | | | 2 | 2.00 | 1 | 8 | | | 18.10 | 19.84 | | | | | 1 | 1 | 40days | 1.20 | .10 |
| Karthiga.S | .75 | 9.00 | 2 | 2119293 | 8/9/2005 | 3 | 1 | 2 | 1 | | | | | 2 | 1.00 | 1 | 10 | | | 20.29 | 19.39 | | | | | 1 | 1 | 10mths | 9.60 | 10.00 |
| Nitheesh Kumar | 1.75 | 21.00 | 1 | 2164427 | 3/1/2006 | 2 | 2 | 1 | 2 | ACD | FFL | | | 2 | 2.00 | 1 | 2 | | | 21.57 | 21.72 | | | | | 1 | 1 | 1yr9mt | 21.00 | 1.00 |
| Abijith | .15 | 1.80 | 1 | 2178330 | 7/2/2006 | 2 | 2 | 1 | 1 | | | | | 2 | 2.00 | 1 | 1 | | | | | | | | | 1 | 1 | 48days | 1.20 | 1.50 |
| Jana .S | .75 | 9.00 | 1 | 2039437 | 23/03/200 | 2 | 2 | 1 | 2 | ACD | FFL | | | 2 | 1.00 | 1 | 8 | | | 20.38 | 19.42 | | | | | 1 | 1 | 10mths | 9.00 | .50 |
| Shobiga.R | 1.50 | 18.00 | 2 | 2043264 | 3/2/2006 | 1 | 2 | 1 | 1 | | | | | 2 | 2.00 | 1 | 6 | | | 20.75 | 20.00 | | | | | 1 | 1 | 1yr6mt | 18.00 | 11.00 |
| Santhosh Kumar. K | .50 | 6.00 | 1 | 2029389 | 19/04/200 | 3 | 1 | 1 | 1 | FFL | FFL | | | 2 | 1.00 | 1 | 8 | | | 21.00 | 21.09 | | | | | 1 | 1 | 9mths | 9.00 | 7.00 |
| B/OAnbuselvi | .10 | 1.20 | 2 | 2155315 | 7/2/2006 | 2 | 2 | | 3 | | | | | 2 | 2.00 | 1 | 2 | | | 18.00 | 18.00 | | | | | 1 | 1 | 66days | 1.80 | 2.00 |
| Nivetha.M | 5.00 | 60.00 | 2 | 2025761 | 7/4/2005 | 1 | 1 | 2 | 1 | 1/60 | 6/12 | 6/9 | | 2 | 1.00 | 1 | 8 | 14 | 15 | 25.25 | 22.92 | 43.00 | 45.00 | 43.50 | 44.25 | 1 | 1 | 5yrs | 60.00 | 36.00 |
| Kiruthika | 4.00 | 48.00 | 2 | 2068125 | 17/05/200 | 3 | 1 | 1 | 1 | 3/60 | 3/60 | | | 2 | 2.00 | 1 | 8 | 16 | 12 | 22.02 | 22.01 | 40.00 | 42.25 | 40.00 | 42.25 | 1 | 1 | 4yrs | 48.00 | 48.00 |
| Muthupandi | 5.00 | 60.00 | 1 | 1990219 | 16/11/200 | 1 | 2 | 1 | 1 | 6/6 | HM | 6/6 | HM | 2 | 2.00 | 1 | 2 | 14 | 12 | 23.26 | 23.30 | 42.50 | 43.00 | 42.00 | 43.75 | 1 | 1 | 5yrs | 60.00 | .30 |
| Dhinesh Rajan .K | 4.00 | 48.00 | 1 | 2097286 | 20/07/200 | 1 | 2 | 1 | 1 | 6/12 | PL+ | | | 2 | 2.00 | 1 | 2 | 13 | 12 | 23.13 | 23.02 | 40.50 | 42.00 | 41.00 | 42.00 | 1 | 1 | 4yrs | 48.00 | .50 |
| Mohammed Razal | 2.00 | 24.00 | 1 | 2091588 | 8/7/2005 | 1 | 2 | 1 | 1 | 6/7.5 | 6/24 | | | 2 | 2.00 | 1 | 8 | 11 | 12 | 21.87 | 21.20 | | | | | 1 | 1 | 2yrs | 24.00 | 3.00 |
| Prabhakaran | 4.00 | 48.00 | 1 | 2143838 | ######## | 1 | 2 | 1 | 1 | 6/6 | HM | 6/6 | HM | 2 | 2.00 | 1 | 2 | 17 | 14 | 21.40 | 21.17 | 44.35 | 44.75 | 43.75 | 43.25 | 1 | 1 | 4yrs | 48.00 | 4.00 |
| Geyona | 2.00 | 24.00 | 2 | 1991665 | 30/12/200 | 3 | 2 | 1 | 2 | | | | | 2 | 1.00 | 1 | 6 | | | 21.54 | 21.54 | | | | | 1 | 1 | 2yrs | 24.00 | 12.00 |
| Mohammed Basith | 2.00 | 24.00 | 1 | 2050210 | 26/04/200 | 3 | 2 | 1 | 2 | | | | | 2 | 1.00 | 1 | 10 | 16 | 11 | 21.89 | 23.22 | 43.25 | 42.50 | 42.50 | 42.50 | 1 | 1 | 2yrs | 24.00 | 12.00 |
| Mohammed Kasim.S | 2.00 | 24.00 | 1 | 1961675 | 16/08/200 | 2 | 1 | 1 | 1 | | | | | 2 | 2.00 | 1 | 1 | | | 20.01 | 20.57 | | | | | 1 | 1 | 2yrs | 24.00 | .25 |
| Surya.M | 2.00 | 24.00 | 2 | 2038217 | 26/03/200 | 2 | 2 | 1 | 1 | ACD | ACD | | | 2 | 1.00 | 1 | 2 | 15 | 14 | 22.20 | 24.62 | | | | | 1 | 2 | 2yrs | 24.00 | .25 |
| Ganga Rajesh | 2.00 | 24.00 | 2 | 2038573 | 9/3/2005 | 2 | 2 | 1 | 2 | FFL | FFL | | | 1 | 1.00 | 2 | 2 | 10 | 11 | 21.89 | 22.02 | 41.75 | 43.00 | 41.75 | 43.00 | 1 | 1 | 2yrs | 24.00 | 2.00 |
| Sowmiya | 2.00 | 24.00 | 2 | 2047881 | 8/4/2005 | 3 | 2 | 1 | 2 | ACD | ACD | | | 2 | 1.00 | 2 | 2 | | | 22.00 | 20.22 | | | | | 1 | 1 | 2yrs | 24.00 | 24.00 |
| Muneeshwaran | 4.00 | 48.00 | 1 | 2107450 | ######## | 2 | 2 | 1 | 2 | 6/6 | PL+ | | | 2 | 1.00 | 1 | 2 | 17 | 18 | 21.61 | 19.85 | 42.00 | 41.00 | 42.00 | 42.00 | 1 | 1 | 4yrs | 48.00 | .10 |
| Susmitha.K | 9.00 | #### | 2 | 2106007 | 9/8/2005 | 1 | 2 | 1 | 1 | 6/6 | 1/60 | | | 2 | 1.00 | 1 | 8 | 19 | 17 | 22.49 | 22.59 | 43.75 | 44.00 | 43.50 | 43.00 | 1 | 1 | 9yrs | 108.00 | 108.00 |
| Pavankumar | ### | #### | 1 | 2062853 | 7/5/2005 | 1 | 1 | 1 | 1 | 3/60 | 6/6 | | | 2 | 2.00 | 1 | 10 | 18 | 17 | 22.47 | 22.66 | 43.75 | 43.50 | 43.75 | 44.00 | 1 | 1 | 10yrs | 120.00 | 12.00 |
| Anusha.P | ### | #### | 2 | 2138518 | 6/1/2006 | 1 | 2 | 1 | 2 | 6/6 | 1/60 | | | 2 | 2.00 | 1 | 8 | 12 | 13 | 23.18 | 20.61 | 42.50 | 43.00 | 37.00 | 42.50 | 1 | 1 | 10yrs | 120.00 | 8.00 |
| Reimia Rose Thoma | 7.00 | 84.00 | 2 | 2051060 | ######## | 1 | 2 | 1 | 1 | 6/6 | FCF | | | 2 | 2.00 | 1 | 11 | 10 | 14 | 22.96 | 22.79 | 42.25 | 42.75 | 42.00 | 42.75 | 1 | 1 | 7yrs | 84.00 | 12.00 |
| Suriyanarayanan | 8.00 | 96.00 | 1 | 2045537 | 19/04/200 | 1 | 2 | 1 | 1 | 6/6 | 5/60 | | | 2 | 2.00 | 1 | 6 | 14 | 12 | 23.48 | 23.10 | 42.50 | 42.75 | 42.50 | 42.75 | 1 | 1 | 8yrs | 96.00 | .25 |
| Lakshmi.A | ### | #### | 2 | 2045026 | 24/03/200 | 1 | 1 | 1 | 1 | 6/36 | 6/6 | 6/12 | 6/6 | 2 | 2.00 | 1 | 6 | 20 | 20 | 23.98 | 23.08 | 43.50 | 44.50 | 44.25 | 44.50 | 1 | 1 | 14yrs | 168.00 | 24.00 |
| Rajapandi | ### | #### | 1 | 1733101 | 6/1/2006 | 1 | 2 | 1 | 1 | 6/12 | PL+ | 6/6 | | 2 | 2.00 | 1 | 2 | 25 | 25 | 25.17 | 25.62 | 41.00 | 42.00 | 40.00 | 42.00 | 1 | 2 | 12yrs | 144.00 | .25 |
| Eswaran | ### | #### | 1 | 533673 | 2/6/2005 | 1 | 1 | 1 | 1 | HM | 6/6 | HM | 6/6 | 2 | 1.00 | 1 | 3 | 17 | 17 | 22.68 | 22.59 | 42.50 | 43.00 | 43.00 | 43.00 | 1 | 1 | 11yrs | 132.00 | 6.00 |
| Vignesh.R | 8.00 | 96.00 | 1 | 2163597 | 20/01/200 | 1 | 2 | 1 | 1 | 6/6 | 6/36 | 6/6 | 6/36 | 2 | 2.00 | 1 | 3 | 18 | 18 | 22.29 | 21.86 | 44.00 | 44.00 | 43.50 | 44.00 | 1 | 1 | 8yrs | 96.00 | .50 |
| Sabiya | ### | #### | 2 | 2027693 | ######## | 1 | 2 | 1 | 1 | 6/6 | 6/36 | | | 2 | 2.00 | 1 | 6 | 17 | 14 | 23.30 | 22.60 | 42.50 | 43.25 | 42.00 | 43.50 | 1 | 1 | 15yrs | 180.00 | 12.00 |
| Nivas.V | ### | #### | 1 | 2051532 | ######## | 1 | 2 | 1 | 1 | 6/6 | 6/24 | | | 2 | 2.00 | 1 | 6 | 12 | 11 | 22.76 | 22.76 | 43.00 | 43.00 | 43.00 | 43.50 | 1 | 1 | 11yrs | 132.00 | 6.00 |
| Musthafa Raja Moha | 8.00 | 96.00 | 1 | 2011232 | 3/5/2005 | 1 | 2 | 1 | 1 | 6/36 | 6/36 | 6/6 | | 2 | 2.00 | 1 | 10 | 14 | 10 | 23.74 | 23.18 | 45.00 | 45.00 | 44.00 | 45.00 | 1 | 1 | 8yrs | 96.00 | 3.00 |
| Savad .P.M. | 8.00 | 96.00 | 1 | 1816784 | 25/10/200 | 1 | 1 | 1 | 1 | 1/60 | 6/6 | 1/60 | 6/6 | 2 | 2.00 | 1 | 9 | 12 | | 26.89 | 23.17 | 43.00 | 45.00 | 42.25 | 43.00 | 2 | 1 | 8yrs | 96.00 | 16.00 |
| Vishwanath.V | 9.00 | #### | 1 | 1927388 | 3/6/2004 | 1 | 2 | 1 | 2 | 6/36 | 3/60 | 6/9 | | 2 | 1.00 | 1 | 3 | 12 | 10 | 24.44 | 24.83 | 43.50 | 45.00 | 44.00 | 45.50 | 1 | 1 | 9mths | 9.00 | 7.00 |
| Logapriya | ### | #### | 2 | 2180333 | ######## | 1 | 1 | 1 | 1 | 0.5/60 | 6/6 | | | 2 | 2.00 | 1 | 3 | 16 | 15 | 21.37 | 20.57 | 44.75 | 45.50 | 45.50 | 45.50 | 1 | 1 | 10yrs | 120.00 | 1.00 |
| Ramani | ### | #### | 2 | 1987000 | 22/10/200 | 1 | 2 | 1 | 1 | 6/6 | FCF | | | 2 | 2.00 | 1 | 2 | 18 | 16 | 22.55 | 22.69 | 43.75 | 45.50 | 44.00 | 45.50 | 1 | 1 | 12yrs | 144.00 | 1.00 |
| Nikesh | 8.00 | 96.00 | 1 | 1959469 | 17/08/200 | 1 | 2 | 1 | 1 | 6/6 | 6/12 | | | 2 | 2.00 | 1 | 10 | 18 | 17 | 22.97 | 23.00 | 41.75 | 42.50 | 41.50 | 42.25 | 1 | 1 | 8yrs | 96.00 | 8.00 |

| TYPSUR1 | IOLIMP | INFLAM | F1DATE | F1VAIE | F1BCVA | F1FIXRE | F1FIXLE | F1AXIAR | F1AXIAL | F1K1RE | F1K2RE | F1K1LE | F1K2LE | F1IOPRE | F1IOPLE | F1ANT | F1POSEG | F2DATE | F2VAIE | F2BCVAI | F2FIXRE | F2FIXLE | F2AXIAR | F2AXIAL | F2K1RE | F2K2RE | F2K1LE | F2K2LE | F2IOPRE | F2IOPLE | F2ANT | F2POSEG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | | 3 | 16/09/200 | | | 1 | 2 | | | | | | | 9 | 8 | 1 | 1 | | | | 1 | 2 | 20.02 | 20.01 | | | | | 8 | 10 | 1 | 1 |
| 6+5 | 30.00 | 3 | 8/5/2005 | | | 2 | 1 | | | | | | | | | | | 08-Aug-2005 | | | 2 | 1 | 18.01 | 19.94 | | | | | | | | |
| 6 | | 3 | 27/06/200 | | | 2 | 1 | 18.38 | 20.39 | | | | | | | 1 | 1 | | ACI | | 1 | 1 | 19.00 | 21.65 | | | | | | | 1 | 1 |
| 4+5 | 23.50 | 3 | ######## | | | 2 | 1 | | | | | | | | | 1 | 1 | | ACI | | 1 | 1 | 20.34 | 19.68 | | | | | | | 1 | 1 |
| 4 | 22.50 | 3 | 3/2/2006 | ACI | | 1 | 2 | | | | | | | | | 1 | 1 | | ACI | | 1 | 2 | | | | | | | 10 | 10 | 1 | 1 |
| 6 | | 3 | 13/03/200 | | | 1 | 1 | | | | | | | | | 1 | 1 | | | | 1 | 1 | 19.14 | 17.73 | | | | | 12 | 10 | 1 | 1 |
| 3 | 23.00 | 3 | 18/04/200 | FFL | | 1 | 2 | | | | | | | | | 1 | 1 | 08-Sep-2005 | ACI | | 1 | 2 | 21.35 | 19.57 | | | | | 10 | 12 | 1 | 1 |
| 4 | 25.00 | 1 | 3/3/2006 | FFL | | 1 | 1 | | | | | | | 15 | 16 | 1 | 1 | | FFL | | 1 | 1 | 21.12 | 20.00 | | | | | 12 | 9 | 1 | 1 |
| 3 | | 3 | 23/05/200 | | | 1 | 1 | | | | | | | | | 1 | 1 | | | | 1 | 1 | | | | | | | | | 1 | 1 |
| 6 | | 3 | 18/03/200 | | | 1 | 2 | | | | | | | | | | | 06-Jan-2006 | | | 1 | 1 | 19.10 | 19.00 | | | | | | | 1 | 1 |
| 2+5 | 15.50 | 1 | 13/05/200 | 1/60 | | 2 | 1 | | | | | | | 11 | 14 | 1 | 1 | 11-Oct-2005 | 1/60 | | 2 | 1 | 25.50 | 22.94 | 43.50 | 43.00 | 43.50 | 44.25 | 15 | 16 | 1 | 1 |
| 2 | 26.50 | 3 | 23/06/200 | 4/60 | 6/36 | 1 | 1 | | | | | | | 10 | 11 | 1 | 1 | 12-Aug-2005 | 4/60 | 6/36 | 1 | 1 | | | 38.63 | 35.75 | 39.00 | 42.00 | 12 | 13 | 1 | 1 |
| 4 | 20.00 | 3 | ######## | 5/60 | 6/36 | 1 | 1 | | | | | | | 14 | 12 | 1 | 1 | 04-Jun-2005 | 5/60 | 6/24 | 1 | 1 | | | | | | | 13 | 12 | 1 | 1 |
| 4 | 23.00 | 3 | 23/08/200 | 6/12 | 6/12 | 1 | 1 | | | 40.25 | 42.25 | 41.25 | 42.25 | 16 | 10 | 1 | 1 | | | | | | | | | | | | | | | |
| 2 | 24.00 | 3 | 9/8/2005 | 6/19 | | 1 | 1 | | | | | | | | | 1 | 1 | | 6/19 | | 1 | 1 | 21.94 | 21.20 | | | | | 10 | 13 | 1 | 1 |
| 3 | 25.00 | 1 | 30/11/200 | 2/60 | 2/60 | 1 | 1 | | | | | | | 14 | 9 | 1 | 1 | | 6/18 | | 1 | 1 | 21.16 | 21.17 | 44.62 | 44.00 | 44.00 | 43.25 | 14 | 13 | 1 | 1 |
| 4+5 | 23.00 | 3 | 2/2/2005 | | | 1 | 1 | | | | | | | 14 | 14 | | | 06-Feb-2005 | | | 1 | 1 | 21.88 | 21.53 | | | | | 13 | 13 | 1 | 1 |
| 3+5 | 23.00 | 3 | 24/11/200 | | | 1 | 1 | 21.90 | 23.30 | 43.25 | 42.50 | 42.50 | 43.50 | 14 | 15 | 1 | 1 | | | | | | | | | | | | | | | |
| 4 | 23.00 | 3 | 20/09/200 | ACI | | 2 | 1 | | | | | | | | | 1 | 1 | | ACI | | 2 | 1 | 20.02 | 20.57 | | | | | | | | |
| 3 | 15.00 | 3 | 13/05/200 | ACI | | 1 | 1 | | | | | | | 10 | 13 | 1 | 1 | | ACI | | 1 | 1 | 22.30 | 24.62 | | | | | 14 | 15 | 1 | 1 |
| 6 | | 3 | 13/04/200 | FFL | | 1 | 2 | | | | | | | 20 | 15 | 1 | 1 | | FFL | | 1 | 2 | | | | | | | | | | |
| 1 | | 3 | ######## | FFL | | 1 | 2 | | | | | | | 11 | 22 | 2 | 1 | 11-Sep-2005 | | | 1 | 2 | 22.04 | 20.87 | | | | | | | 1 | 1 |
| 2+5 | 30.00 | 3 | 27/08/200 | HM | | 1 | 2 | | | | | | | 16 | 18 | 1 | 1 | | HM | | 1 | 2 | 21.62 | 19.90 | 42.00 | 41.00 | 42.00 | 43.00 | 14 | 14 | 1 | 1 |
| 2+5 | 23.50 | 3 | 3/9/2005 | 2/60 | 2/60 | 1 | 1 | | | | | | | 10 | 11 | 1 | 1 | 03-Jul-2006 | 2/60 | 2/60 | 1 | 1 | 22.59 | 22.59 | 43.75 | 44.00 | 45.25 | 42.50 | 16 | 18 | 1 | 1 |
| 2 | 23.50 | 3 | 17/06/200 | 2/60 | 3/60 | 1 | 1 | | | | | | | 16 | 16 | 1 | 1 | | 3/60 | 3/60 | 1 | 1 | 22.55 | 23.11 | 43.25 | 44.00 | 43.37 | 44.62 | 13 | 14 | 1 | 1 |
| 2 | 30.00 | 3 | 8/3/2006 | 5/60 | 5/60 | 1 | 2 | | | | | | | 14 | 11 | 1 | 1 | | 5/60 | 5/60 | 1 | 2 | 23.20 | 20.61 | 42.50 | 43.00 | 39.00 | 42.00 | 16 | 17 | 1 | 1 |
| 2 | | 3 | 16/05/200 | 5/60 | 6/18 | 1 | 1 | 23.09 | 22.79 | | | | | 14 | 16 | 1 | 1 | 09-Sep-2005 | 5/60 | 6/18 | 1 | 1 | 23.09 | 22.79 | 42.25 | 42.75 | 42.00 | 42.75 | 10 | 12 | 1 | 1 |
| 4 | 22.00 | 3 | 23/05/200 | 6/12 | 6/6 | 1 | 1 | | | | | | | 18 | 16 | 1 | 1 | 11-May-2005 | 6/12 | 6/6 | 1 | 1 | 23.33 | 23.13 | 43.00 | 43.00 | 42.50 | 43.00 | 21 | 22 | 1 | 1 |
| 2 | 19.00 | 3 | 23/11/200 | 6/12 | 6/9 | 1 | 1 | 24.00 | 23.75 | 43.50 | 44.50 | 44.00 | 45.00 | 15 | 16 | 1 | 1 | | | | | | | | | | | | | | | |
| 2 | 17.00 | 3 | 8/2/2006 | 6/18 | 6/6 | 1 | 1 | | | | | | | 22 | 21 | 1 | 1 | | 6/18 | 6/6 | 1 | 1 | 25.17 | 25.62 | 41.00 | 42.00 | 40.00 | 42.50 | 20 | 21 | 1 | 1 |
| 2 | 23.50 | 3 | 5/7/2005 | 6/36 | 6/36 | 1 | 1 | | | | | | | 14 | 13 | 1 | 1 | | 6/24 | | 1 | 1 | 22.68 | 22.59 | | | | | 16 | 14 | 1 | 1 |
| 2 | 25.00 | 3 | 22/02/200 | 6/24 | 6/12 | 1 | 1 | | | | | | | 16 | 19 | 1 | 1 | 07-Jan-2006 | 6/24 | 6/12 | 1 | 1 | 22.29 | 21.86 | 44.00 | 44.00 | 43.00 | 44.50 | 18 | 19 | 1 | 1 |
| 2 | 23.50 | 3 | ######## | 6/6 | | 1 | 1 | | | | | | | 14 | 10 | 1 | 1 | 09-Sep-2005 | 6/36 | 6/24 | 1 | 1 | | | | | | | 12 | 10 | 1 | 1 |
| 3 | 23.00 | 3 | 16/05/200 | 6/18 | 6/12 | 1 | 1 | | | 44.38 | 44.25 | 44.25 | 43.00 | 16 | 16 | 1 | 1 | | 6/24 | 6/12 | 1 | 1 | | 22.98 | 44.38 | 44.25 | 44.25 | 43.00 | 16 | 16 | 1 | 1 |
| 2 | 20.50 | 3 | 8/6/2005 | 6/60 | 6/36 | 1 | 1 | | | | | | | 15 | 13 | 1 | 1 | 12-Oct-2005 | 6/36 | | 1 | 1 | 24.05 | 23.55 | 44.50 | 45.00 | 44.00 | 44.50 | 13 | 13 | 1 | 1 |
| 4 | 11.50 | 3 | 16/11/200 | 6/60 | 6/60 | 1 | 1 | 26.89 | 23.18 | 43.50 | 45.25 | 42.25 | 43.00 | 10 | 13 | 1 | 2 | 03-Dec-2005 | 6/60 | 6/36 | 1 | 1 | 26.89 | 23.18 | 43.50 | 45.25 | 42.25 | 43.00 | 13 | 12 | 1 | 2 |
| 2+5 | 16.00 | 1 | ######## | 5/60 | 6/60 | 1 | 1 | | | 43.50 | 45.00 | 45.75 | 44.50 | 14 | 14 | 1 | 1 | 10-Jul-2005 | 6/60 | 6/36 | 1 | 1 | 24.44 | 24.83 | 43.50 | 45.00 | 44.50 | 45.75 | 14 | 14 | 1 | 1 |
| 2 | 28.50 | 3 | 4/3/2006 | 5/60 | 6/36 | 1 | 1 | | | | | | | 15 | 15 | 1 | 1 | | 6/60 | 6/36 | 1 | 1 | 21.37 | 20.51 | 46.00 | 47.00 | 47.12 | 46.00 | 10 | 12 | 1 | 1 |
| 2 | 22.00 | 1 | ######## | 6/9 | | 1 | 1 | 22.55 | 22.69 | 43.50 | 43.50 | 44.00 | 44.75 | 17 | 18 | 1 | 1 | | | | | | | | | | | | | | | |
| 2 | 22.50 | 3 | 21/09/200 | 6/9 | 6/9 | 1 | 1 | | | | | | | 20 | 20 | 1 | 1 | | 6/9 | | 1 | 1 | 23.04 | 23.10 | 43.00 | 44.00 | 42.75 | 43.50 | 17 | 17 | 1 | 1 |

| F3DATE | F3VAIE | F3AXIS | F3BCVA | F3FIXRE | F3FIXLE | F3AXIAR | F3AXIAL | F3K1RE | F3K2RE | F3K1LE | F3K2LE | F3IOPRE | F3IOPLE | F3ANT | F3POSEG | PCO | ADDIN | AMBLY | SPEC | BSV | FOLDUR | FFUE | FILTER_$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | 2 | | 1 | 1 | 3 | 6.00 | .75 | 0 |
| 02-Oct-2006 | ACL | 90 | | 1 | 1 | 18.01 | 20.28 | | | | | | | | | 2 | 5 | 1 | | 3 | 10.00 | 1.46 | 0 |
| | ACL | | | 1 | 1 | 19.22 | 22.20 | | | | | | | 1 | 1 | 2 | | 1 | 1 | 3 | 18.00 | 2.36 | 0 |
| | ACL | | | 1 | 1 | 20.34 | 19.71 | | | | | | | 1 | 1 | 2 | | 1 | | 3 | 6.00 | .32 | 0 |
| 05-Feb-2006 | ACL | | | 1 | 2 | 21.57 | 21.72 | | | | | 11 | 10 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 6.00 | .00 | 0 |
| | | | | | | | | | | | | | | | | 2 | | 1 | 1 | 3 | 6.00 | | 0 |
| | FFL | | | 1 | 2 | 21.39 | 19.42 | | | | | | | | | 1 | 4 | 1 | | 3 | 9.00 | 1.01 | 0 |
| | | | | | | | | | | | | | | | | 2 | | 1 | 1 | 3 | 6.00 | .37 | 0 |
| | | | | 1 | 1 | 21.30 | 21.71 | | | | | | | 1 | 1 | 2 | | 1 | | 3 | 9.00 | .62 | 0 |
| | | | | | | | | | | | | | | | | 2 | | 2 | 1 | 3 | 6.00 | 1.10 | 0 |
| | | | | | | | | | | | | | | | | 2 | | 2 | | 2 | 7.00 | .02 | 1 |
| | | | | | | | | | | | | | | | | 2 | | 2 | | 3 | 7.00 | | 0 |
| | 5/60 | 90 | 6/36 | 1 | 1 | 23.25 | 23.31 | 42.50 | 43.00 | 42.00 | 43.00 | | | | | 2 | | 1 | 1 | 2 | 6.00 | -.01 | 1 |
| | | | | | | | | | | | | | | | | 2 | | 2 | | 3 | 12.00 | | 0 |
| 06-Dec-2006 | 6/15 | 180 | 6/15 | 1 | 1 | 22.25 | 21.40 | 41.25 | 39.75 | 42.75 | 41.75 | 10 | 14 | 1 | 1 | 1 | 3 | 1 | 1 | 2 | 11.00 | .38 | 1 |
| | | | | | | | | | | | | | | | | 2 | | 1 | 2 | 1 | 6.00 | -.24 | 1 |
| | | | | 1 | 1 | 21.89 | 21.55 | | | | | 13 | 12 | 1 | 1 | 2 | | 1 | 1 | 3 | 15.00 | .35 | 0 |
| | | | | | | | | | | | | | | | | 2 | | 2 | 1 | 3 | 6.00 | .01 | 0 |
| | | | | | | | | | | | | | | | | 2 | | 1 | 1 | 3 | 6.00 | .00 | 0 |
| | ACL | | | 1 | 1 | 22.30 | 24.62 | | | | | 14 | 15 | 1 | 1 | 2 | | 1 | | 1 | 11.00 | .10 | 1 |
| | FFL | | | 1 | 2 | 22.00 | 22.03 | | | | | | | 1 | 1 | 2 | | 1 | 1 | 3 | 6.00 | .11 | 0 |
| | | | | | | | | | | | | | | | | 2 | | 1 | 1 | 3 | 7.00 | .04 | 0 |
| | | | | | | | | | | | | | | | | 2 | | 2 | | 3 | 6.00 | .01 | 0 |
| | | | | | | | | | | | | | | | | 2 | | 2 | | 3 | 7.00 | .10 | 0 |
| | | | | | | | | | | | | | | | | 2 | | 1 | 1 | 2 | 12.00 | .45 | 1 |
| | | | | | | | | | | | | | | | | 2 | | 1 | 1 | 2 | 6.00 | .02 | 1 |
| | | | | | | | | | | | | | | | | 2 | | 2 | | 3 | 7.00 | .13 | 0 |
| 03-Apr-2006 | 6/12 | 180 | 6/6 | 1 | 1 | 23.33 | 23.13 | 43.00 | 43.00 | 42.50 | 43.00 | 18 | 22 | 1 | 1 | 2 | | 2 | 1 | 1 | 12.00 | -.15 | 1 |
| | | | | | | | | | | | | | | | | 2 | | 2 | 1 | 2 | 8.00 | .67 | 1 |
| | | | | | | | | | | | | | | | | 2 | | 2 | 1 | 1 | 6.00 | .00 | 1 |
| | | | | | | | | | | | | | | | | 2 | | 1 | 2 | 2 | 6.00 | .00 | 1 |
| | | | | | | | | | | | | | | | | 2 | | 2 | 1 | 3 | 6.00 | .00 | 0 |
| | 6/36 | | 6/24 | | | 23.33 | 22.66 | 42.50 | 43.25 | 42.00 | 42.50 | 14 | 14 | 1 | 1 | 2 | | 1 | 1 | 2 | 7.00 | .03 | 1 |
| 03-Sep-2006 | 6/36 | 90 | 6/12 | 1 | 1 | 22.89 | 22.90 | 44.00 | 44.25 | 44.25 | 43.00 | 20 | 18 | 1 | 1 | 2 | | 2 | 1 | 1 | 11.00 | .13 | 1 |
| | | | | | | | | | | | | | | | | 2 | | 1 | 1 | 2 | 7.00 | .31 | 1 |
| 09-Mar-2005 | 6/60 | 180 | 6/36 | 1 | 1 | 26.89 | 23.18 | 43.50 | 45.25 | 42.25 | 43.00 | 10 | 13 | 1 | 2 | 2 | | 1 | 1 | 2 | 11.00 | .01 | 1 |
| | | | | | | | | | | | | | | | | 1 | 3 | 1 | 1 | 2 | 16.00 | .00 | 1 |
| | | | | | | | | | | | | | | | | 2 | | 1 | 1 | 2 | 6.00 | -.06 | 1 |
| | | | | | | | | | | | | | | | | 2 | | 2 | 1 | 1 | 6.00 | .00 | 1 |
| | 6/9 | | | 1 | 1 | 23.04 | 23.10 | 43.00 | 44.00 | 42.75 | 43.50 | 17 | 17 | 1 | 1 | 2 | | 2 | | 1 | 12.00 | .07 | 1 |